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THE PARATHYROID GLANDULES. THEIR BLOOD SUPPLY, AND THEIR PRESERVATION IN OPERATION UPON THE THYROID GLAND.

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THE BLOOD SUPPLY OF THE HUMAN PARATHYROID GLANDULES. HERBERT M. EVANS. The vascular injections and studies herein reported were made to determine accurately the exact source and position of the blood supply to the parathyroid glands in man. Another aim, that of knowing more of the angiology of the parathyroid gland itself, was also served, but this subject will be reported separately at a later date. I would here express my indebtedness to Professor Halsted at whose suggestion the problem was undertaken, to Professor Mall in whose laboratory the injections were made, to Professor W. G. MacCallum, Dr. H. E. Helmholz and especially Dr. Marshall Fabyan who have kindly given me many opportunities to secure fresh human material, and to Mr. Broedel whose advice I found invaluable in the execution of the drawings.

Methods.—Recent studies in the finer anatomy and histology of mammals have shown many distinct differences so that it would be no longer justifiable to assume that the findings in the dog, for example, must be identical with those in man. Such a contention is especially strengthened in this particular case by the variation in the size and position of the parathyroid bodies in the animals which have thus far been investigated. With a full realization of this, all of the present work was done on human material. Very different circulatory relations than are here reported may be found in all those animals in which the parathyroid glands are imbedded in the thyroid. In the majority of cases the specimen was secured a few hours after death, the entire neck organs being removed en masse. The upper and lower poles of each lateral lobe of the thyroid were then carefully dissected sufficiently to identify the superior and inferior vessels in each case. In most instances, the superior arteries were ligated and the injection mass delivered through the inferior vessels, but in several cases the upper arteries were injected in addition. Though anastomoses generally permitted a partial injection of the opposite side, the two sides were always separately injected. Mercuric sulphide (vermilion) granules in a twenty per cent. gelatin solution were most often used as an injection mass and gave a splendid arterial injection which when long-continued could be made to invade the capillary bed. In several cases, the veins were filled with ultramarine blue and in still others the arteries were injected with india ink, which enters the capillaries with great facility. The entire specimen was immediately cooled in running water and a preliminary dissection made to locate the parathyroid glands. This seemed wise inasmuch as the detection of these glandules was easier in fresh material, in which the natural brownish color was retained, than in specimens in which they were blanched by the preserving fluid. A simple sketch of the position of the parathyroids was then made to be used in identifying them in the final dissection. The specimen was placed in a ten per cent. formalin solution for twenty-four hours, after which the tissues were sufficiently preserved to permit a careful dissection to be

made. Such dissections were accurately charted. Generally the parathyroid glands were ultimately removed, dehydrated in alcohols, and cleared in creosote for further study.

Observations.—Few studies of this region based on actual vascular injections have been made. However, D. A. Welsh,[1] whose excellent paper appeared in 1898, used the injection method. It is unfortunate that no figures of the vascular relations accompanied his study.

One of the first facts which appears after a satisfactory injection is that a special tiny parathyroid artery supplies this gland in every case. This artery may arise from one of the glandular, the muscular, or the œsophageal branches of the inferior thyroid artery, but wherever its origin, it can be seen definitely to supply the parathyroid gland and it alone. One may sometimes see one or two smaller arteries accompanying the parathyroid vessel, but they supply the small fat mass which often surrounds the parathyroid or lies on either side of it; my injections have never demonstrated more than one parathyroid vessel proper, and this enters a distinct hilus in the gland. Though practically all previous studies have not shown any real embedding of the human parathyroid in the tissue of the thyroid, the connective tissue envelope which surrounds the latter gland often appears to split to enclose the parathyroid. It was interesting, then, to observe what vascular connections existed between the capsule of the larger and the smaller glands. Complete injections have uniformly shown only the scantiest blood supply to this connective tissue envestment. It usually consists of a few minute vessels, for the most part capillaries. These are seldom seen to be in any relation with the parathyroid glands and never to be connected with the vascular system of the latter, which is always from the parathyroid arteries. This fact was more striking when observed in a rather unique case in which I found the parathyroids so deeply set in the surface of the thyroid that their surface was barely level with that of the larger gland. Here also there was

[1] Welsh, D. A., Jour. of Anat. and Physiol., 1898.

a definite independence of the vascular system of the parathyroid from that of its immediate surroundings. It is thus quite unlikely, even if not inconceivable that the true capsular vessels of the thyroid could nourish the parathyroids and in those cases in which the lower parathyroids lie below the lower pole of the thyroid, it is all the more improbable.

In practically every case studied, the lower parathyroid artery came from a prominent branch of the inferior thyroid artery. Ten entire specimens were found suitable for accurate plotting. This would ordinarily give twenty opportunities for examining the inferior parathyroid artery, but since the gland was not found in one instance, the actual number of observations was nineteen. In six instances the inferior parathyroid gland was clearly below the lower margin of the thyroid, and the parathyroid artery in these cases coursed as a distinct, usually unbranched, vessel to the hilus of the glandule. The findings of others would indicate that so great a proportion of these cases is probably a unique experience. In such cases, the parathyroid artery has measured between two and three centimeters in length; in all other cases its course is seldom in excess of four or five millimeters.

The upper parathyroid gland invariably has a short artery of supply which may arise from one of the main branches of the inferior thyroid or from an anastomosing ramus joining the superior and inferior thyroid arteries. A very prominent anastomosing channel was found along the posterior margin of the lateral thyroid lobe in eight of twenty instances and in these cases the superior parathyroid artery was a short branch from this channel. Most often, however, the angle at which the parathyroid vessel came off from its parent trunk suggested strongly that its blood stream was usually from the inferior source.

The conditions found thus varied somewhat, but with the constant features just emphasized. The special picture presented will depend to a considerable extent on the position of the parathyroids; and using this as a sort of basis of classification three common types may be specified. Figures 1 and 2

illustrate two varieties of what may be called the first type. Here the upper parathyroid lies along the posterior border of the lateral lobe of the thyroid somewhat above the mid-point between the upper and lower "poles"; the lower glandule lies near the lower thyroid margin or pole. It is not unlikely that this particular arrangement will be found occurring most often in a large series of cases. In Fig. 1, the lower para-

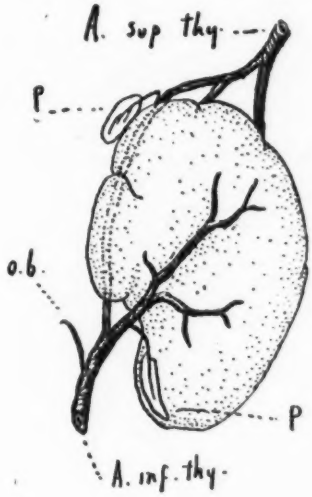


Fig. 1.

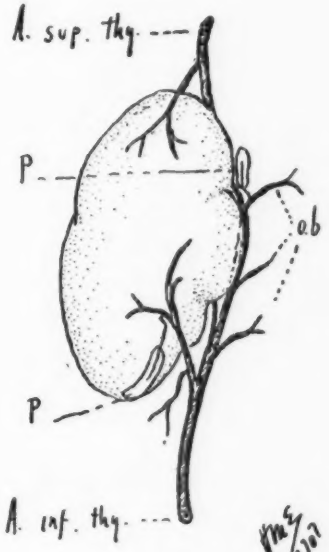


Fig. 2.

thyroid artery is seen to arise from the prominent lateral branch of the inferior thyroid artery which supplies most of the outer surface of the lateral thyroid lobe. The upper parathyroid artery here arises from the strong anastomosing channel between the upper and lower thyroid vessels which courses along the posterior border of the lateral lobe. In Fig. 2, the lower little artery comes from one of the lateral glandular rami of

the inferior thyroid, while the upper one happens to be a branch of the uppermost œsophageal ramus.

Figs. 3 and 4 will illustrate a type but little removed from that just discussed, but one in which the parathyroids are rather symmetrically disposed, the one above, the other below the mid-point between the thyroid poles. The condition shown

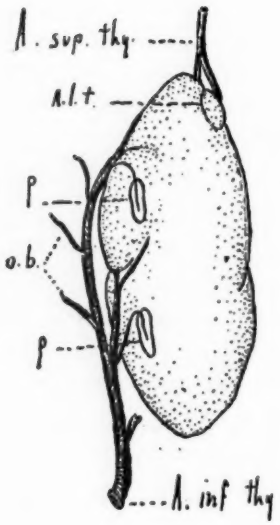


Fig. 3.

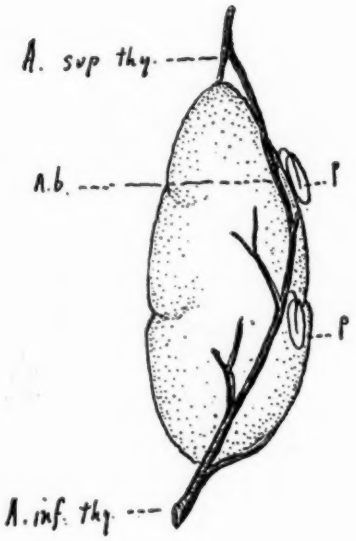


Fig. 4.

in Fig. 4 is interesting since here both parathyroid vessels came from the same large branch of the inferior thyroid, which in this case communicated with the superior thyroid artery.

In the third type, shown in the remaining two figures (5 and 6), is depicted the arrangement seen in those cases in which the lower gland is appreciably below the lower margin

of the thyroid. Here it is not unusual to find a relatively long parathyroid artery.

Various other modifications in the exact plan of blood supply were found, but, in general, the figures given illustrate the chief conditions.

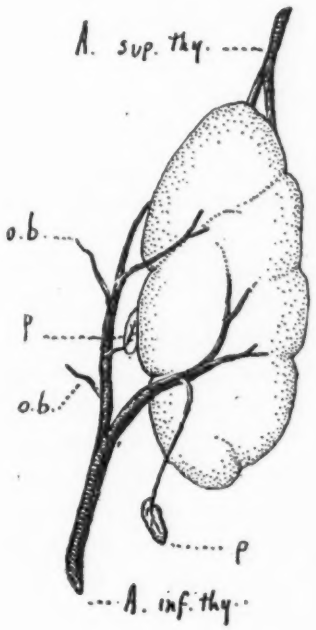


Fig. 5.

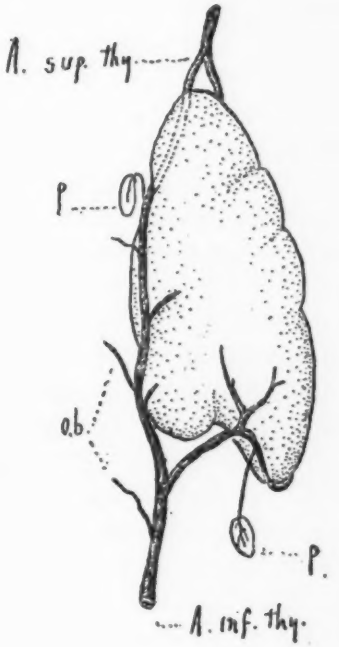


Fig. 6.

It is without the purpose of this communication to follow the behavior of the parathyroid artery after it enters the glandular hilus, but it may be said here that, in general, this vessel pursues a central course, giving off obliquely directed branches which ramify peripherally, eventually giving origin to capillaries. This picture may be seen beautifully in cleared specimens of the glandule and, it may be pointed out, is in

contrast to the scheme of circulation which obtains in the case of the thyroid gland.

The chief facts brought forward in the present report may be summarized as follows:

1. The parathyroid glands are always supplied by definite parathyroid arteries which enter them in each case at the hilus.

2. The parathyroid arteries, superior and inferior, usually arise from the inferior thyroid, but frequently they take origin from the anastomosing channel, described above, between the inferior and superior thyroid vessels. Additional types of origin of the parathyroid artery have been described and figured.

3. Few, if indeed any, direct vascular connections normally exist between the parathyroid glands and the connective tissue envelope of the thyroid.

THE PRESERVATON OF THE PARATHYROID GLANDULES IN OPERATION UPON THE THYROID LOBES. WILLIAM S. HALSTED. With our present knowledge, scant as it is, of the function of the parathyroid bodies comes not only the recognition of the necessity for their preservation but more frequent occasion for operations which imperil the vitality of these little life sustaining organs.

When tetany was believed to be due to thyroid privation the surgeon feared to operate upon both lateral lobes of the thyroid gland, having learned that the death rate from total excision of this organ was very great, and, that tetany, the chief cause of this mortality, might follow the excision of merely one lobe of the thyroid gland or ligation of two or even of one of the four thyroid arteries.

As long ago as 1889 it was discovered that dogs would survive the gradual excision of as much as thirty-one thirty seconds and of even a greater proportion of the thyroid gland provided the fraction remaining was the superior pole of either lobe. That tetany did not result was due to the fact, not surmised until the appearance of Gley's superb contributions in 1891, that the superior parathyroid body, situated in the dog very near to and usually a little above the superior pole of the

thyroid lobe had escaped destruction by this method of piecemeal excision, from below upwards, of the thyroid gland. In man, however, with gradual, piecemeal amputation from below upwards of the thyroid lobes destruction of all of the four parathyroid glandules would, as a rule, already be accomplished with the removal of the lower two thirds, approximately, of each lateral lobe: vid. figs. 2, 3 and 5. But even before it was ascertained that the parathyroid bodies had any function whatever a long series of happy accidents demonstrated that total excision of the thyroid gland might, in man, be survived in about fifty per cent. of the cases; in many instances, moreover, there was entire absence of symptoms of thyroid as well as of parathyroid insufficiency.

Only now that the function of the thyroid gland and the parathyroid glandules may no longer be so confounded, are we in a position to determine the amount of each of these organs likely to be necessary in a given case to prevent the occurrence of symptoms of deficiency of either. And even before this has been more definitely determined surgeons are justified in proceeding with greater intrepidity in operation involving the sacrifice of the thyroid and threatening the destruction of the parathyroid glands, believing that the symptoms of privation of each may be mitigated or entirely negatived by the administration in some form of the nucleoproteids or whatever substances are lacking.[2]

In the mean time our plan of operating not only for the exophthalmic or hypertrophic forms but also for the colloid, degenerative or atrophic varieties of goitre may be modified in conformity to our recently acquired knowledge of the function of the glandulæ parathyreoideæ. In place of the unilateral operation, heretofore almost exclusively practiced in cases of colloid or other nonhypertrophic varieties of goitre, a bilateral

[2] The patient suffering from hypoparathyreosis whose history is reported in the July number of the American Journal of Medical Sciences is rapidly being restored to health by the administration, hypodermically, of the nucleoproteids of the parathyroid glands of beeves, supplied me, most kindly, by Prof. S. P. Beebe, of Cornell, N. Y.

operation might be substituted in some cases; and in the hypertrophic goitres, the one lobe should be so operated upon, that, in case of need, the other may be subsequently attacked without danger of parathyroid privation. Even in the absence of the existing vital reasons which contraindicate the sacrifice of a single parathyroid glandule, the fact that these little organs perform some highly important function is sufficient reason for the endeavor to preserve all of them.

Although for more than a decennium we have known that operative tetany is due to loss of parathyroid tissue more cases of this affection have followed operation during this time than in the preceding quarter century; and, furthermore, at the hands of the operators most experienced in the surgery of the thyroid gland.

Dr. MacCallum, who has carefully studied the operative material from about eighty cases of exophthalmic goitre operated upon by the writer, reports having found in perhaps seven instances one parathyroid with the excised lobe. During the past two years this glandule has only twice, I believe, been excised by me with the thyroid lobe. Nevertheless it is quite certain that in most instances of complete excision of one thyroid lobe as reported by surgeons the world over both parathyroid glandules of the operated side have been sacrificed whether the trunks of the thyroid arteries were tied at some distance from the gland or the ultimate branches of distribution at their points of entrance into the thyroid lobe; and even when that portion of the thyroid in which the parathyroid glandules are quite uniformly found has been resected and left undisturbed, the latter bodies were undoubtedly often destroyed.

It is in the control of hemorrhage that we sacrifice the parathyroid glandules. But the hemorrhage must be controlled and thyroid vessels must somewhere be divided in the operation for the removal of a lobe of the thyroid gland. May they be so divided and secured as not to cut off the blood supply of the parathyroid glandules? Reply to this question is impossible without definite knowledge of the blood supply of these little bodies.

Dr. Mall did me an invaluable service in recommending Mr. Herbert M. Evans, of the class of 1908 of the Medical School of Johns Hopkins University as one particularly well equipped for making the investigations. Mr. Evans[8] undertook the work with enthusiasm, being interested both in the anatomical and the surgical aspect of the problem. Upon his report, which precedes, this paper is based.

The Situation of the Parathyroid Bodies.—Their position in man is, in general, much lower than in dogs, the higher of the two glands of one side being, on the average about at the level of the junction of the upper and middle thirds of the lateral lobe of the thyroid gland. Occasionally a parathyroid is found as high as, or even above the superior pole of the thyroid gland. In one instance at the operating table I happened to find a parathyroid above the level of the superior pole of the thyroid gland. The lower of the two glandules, rarely as high as the middle of the thyroid lateral lobe, is usually not far from the lower pole, but may be several centimetres below it—even within the bony thorax. With great regularity these little epithelial bodies are situated on or very near the posterior border of the lateral lobe of the thyroid gland and more or less in line with an important landmark, the "channel" of anastomosis between the superior and inferior thyroid arteries.

The Blood Supply.—As determined by Mr. Evans each glandule has invariably its special artery which might be designated the superior and inferior parathyroid artery right and left. This little vessel surprises one by its size, being large in proportion to the organ supplied, and thus aids in the identification of the epithelial body. The parathyroid artery is particularly serviceable as a guide to the parathyroid gland when the latter is enveloped in fat. Ordinarily these glandules are quite free and, as cherries on the stem, hang from the artery which, as described by Mr. Evans, enters its "hilus."

The usual shape of the bodies is indicated in the drawings.

[8] In another communication Mr. Evans will give in greater detail the result of his study of the circulation of the parathyroid glandule.

They are ordinarily ovoid and flattish, presenting a sharpish edge which may as a rule be easily curled or folded. The surface markings which give the glandule an exceedingly fine, barely visible granular appearance are probably due to the blood vessels. Differentiation from adipose or thyroid tissue is rarely difficult unless the natural appearances have been obscured by trauma or staining.

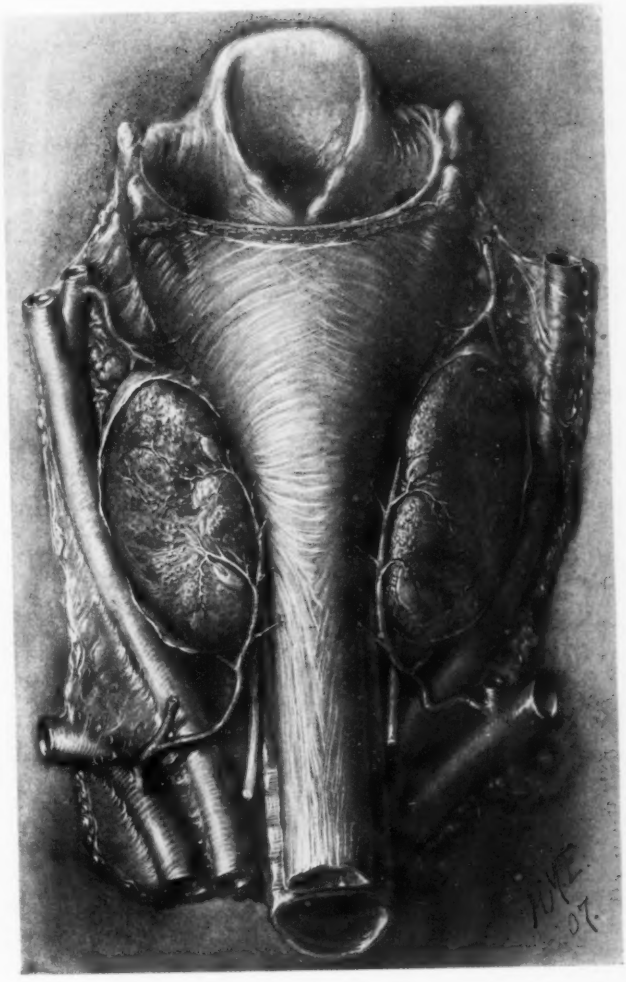
To Save the Parathyroid Glands in Performing Thyroid Lobectomy.—We have seen that from the superior and inferior thyroid the parathyroid arteries almost invariably arise, but we may assume that by the way of the œsophageal or other branches of anastomosis a number of parathyroid glands have been rescued; otherwise it would be difficult to explain the large percentage of recoveries which followed simultaneous ligation in man of all four of the thyroid arteries in the total excisions of a quarter of a century ago. It is important to note that these excisions were not undertaken for the hypertrophic forms of goitre.

Total extirpation performed in this manner in cases of Graves' disease would, perhaps, rarely fail to be followed by tetany. But it frequently happens that more than one lobe, or indeed that the greater portion of both lobes has, in two or more acts, to be removed in hypertrophy of the thyroid gland.

The "subcapsular" proceedure of Dr. Chas. H. Mayo, is, I believe, correct in principle, and, with the proper observance of details, for knowledge of which we are indebted to more complete acquaintance with their vascular supply, one or perhaps both parathyroid glandules of a side may be saved. But only with the exercise of the greatest caution; for, between the point at which the branch giving off the parathyroid artery enters the thyroid lobe and the origin of the latter vessel, there may be hardly room for one fine pointed artery forceps and not space for a broader-nosed clamp, as, for example, the admirable instrument of Ochsner; and still less for two clamps.

On two occasions, recently, in the operation for exopthalmic goitre, there was not room even for the fine point of our "mosquito clamp," and twice I deliberately cut off the blood

FIG. 7.



Parathyroid Glandules.

supply of the inferior parathyroid gland seeing no alternative save preserving a portion, too considerable, of the thyroid lobe. On several occasions, operating for exophthalmic goitre, I have transplanted into the thyroid gland a parathyroid glandule which had been deprived of its blood supply.

The drawings of Mr. Evans happen to be made from specimens which do not illustrate this point particularly well; but in figures 2 and 7 the inferior parathyroid is given off from a branch of the inferior thyroid artery only a few millimetres from the point at which the latter penetrates the thyroid gland. In fig. 3, also, the inferior glandule, a centimetre or more below the inferior pole of the thyroid gland, might easily be deprived of its blood supply if its artery were not recognized in the course of the operation. There is room in this instance for the application of 2 ordinary artery clamps distal to the point of origin of the parathyroid arteriole; but it should be observed that a nicely injected, carefully dissected specimen makes plain conditions which, in the course of an operation might be overlooked. The remaining glandules of the illustrations might with care escape destruction, for their arterioles are very short and arise in the main from the anastomotic channel or quite near to this vessel.

The term " subcapsular " expresses the operation of ultra-ligation very well, it seems to me, and I find it exceedingly convenient. It may be objected that there is normally no demonstrable capsule underneath or in the plane of the blood vessels of the thyroid gland, but the term proposed by Mayo is, nevertheless, not confusing and will not easily be relinquished. As a matter of fact there is not infrequently in cases of goitre, an intimate capsule enmeshing the vessels, which can not only be seen during the dissection but demonstrated thereafter.

The Operation of Ultra-ligation in Exophthalmic Goitre. —The operation of ultra-ligation or ligation beyond the origin of the parathyroid arterioles is quite simple if properly performed, but may prove very difficult, if not. The skin incision is usually made to correspond with one of the transverse lines of the neck, its length depending upon the size of the goitre

and upon the height of the superior pole of the thyroid. For a better cosmetic effect, in the case of women, we often determine the precise line for the incision with the patient in a sitting posture, consulting her as to the fall of the necklaces which she wears with evening dress. If the line is prescribed in the recumbent position the scar may fall too low. The platysma muscle, carefully reflected upwards in the skin flap, may be divided at a slightly higher level than the skin. In the dissection of this flap and indeed throughout the operation the injury to veins should be avoided as studiously as possible. A vertical, mid-line incision through the fascia is carried only deep enough to enable one to raise the sterno-hyoid and omo-hyoid muscles. It is an excellent suggestion of Chas. Mayo's to divide these muscles near their hyoid insertion, and between clamps which are not removed until it becomes necessary to do so, to permit the placing of the muscle suture.

It has not been my practice, however, to include in these clamps, the sterno-thyroid muscle. I believe that one is less likely to stain the deep wound if the sterno-thyroid muscle is carefully divided by itself after the hyoid muscles have been reflected, and in such a manner as not to cause the rupture of the fine and easily torn vessels which one encounters in raising this thinly spread out, capsule-like muscle from the thyroid gland. Moreover, one cannot reflect the omo-hyoid and sterno-hyoid muscles to so high a point if the sterno-thyroid muscle is included. The latter muscle being well divided and the previously severed muscles forcibly reflected by means of the strong muscle-clamps, one may gently raise the thyroid lobe from its bed on a spatula-like knife handle carefully insinuated between the delicate blood vessels just coming into view.

Contrary to the universal custom, I do not as a rule, complete at this moment the full delivery of the entire gland, for fear of soiling, but grasp very firmly between thumb and finger the superior pole and pull it forwards and towards the mid-line far enough to make the ultra-ligation of the superior thyroid vessels perfectly easy. Attempts to completely dislocate the entire gland or the inferior pole in this manner at this

stage of the operation may cause the rupture of some delicate blood vessels and consequent staining of the field containing the parathyroid glandules. But, if judiciously done in the manner described, the superior pole may be fearlessly grasped, because at this horizontal level there are no vessels behind the superior pole likely to be torn. When the superior thyroid vessels have been safely passed by the thumb or finger one may proceed with considerable roughness and without fear of hemorrhage to dislocate even the highest and deepest superior pole.

This grasp of the upper portion of the lobe putting on stretch the superior thyroid vessels must not be relinquished until released by the ultra-division of the finest branches distributed to the thyroid gland in the vicinity of the superior pole. The upper end being thus liberated the delivery of the entire lobe is continued, and without the tearing of the blood vessels. From this step on, throughout the operation, until the last vessel has been divided the thyroid lobe must be firmly drawn towards the opposite side, alternate relaxation and compression and undue pressure on the trachea being carefully avoided. From above downwards and from before backwards the vessels as they bind or as they present must be clamped and divided at their point of entrance into the gland, as far peripherally as possible.

Except in the case of the larger branches it is usually unnecessary to clamp the distal end of the cut vessel, hemorrhage from the gland side being prevented by the pressure exerted on the thyroid lobe by the unremitting traction towards the opposite side of the neck. By this method the recurrent laryngeal nerve, usually seen, is little endangered. In the course of the liberation of the lobe the nerve may be dragged well to the front of the trachea: of the right nerve this is particularly true. When in the immediate neighborhood of this nerve, at what might erroneously be termed the hilus of the thyroid lobe, one plunges the sharp pointed clamps into the thyroid gland, seizing the binding vessels after they have disappeared from view in its substance. When the habit is well

acquired little if any time is lost by practicing the clean, bloodless method of operating for goitre. The operation can be carefully performed in about the time required for its detailed description. For the removal of a thyroid lobe in a moderately difficult case of exophthalmic goitre, ten minutes is ample time if the experienced, skillful operator is well assisted.

I am not convinced that very light general anæsthesia with ether skillfully given by an expert anæsthetist for only fifteen or twenty minutes is less safe, even in the gravest cases, than local anæsthesia plus the prolonged operative period and its attendant nerve strain. In operations for exophthalmic goitre the general anæsthesia should be administered only by an expert.

A nurse trained in the præ- and post-operative care of cases of Graves' disease should be in charge, and the patient should have a private, quiet room. We have knowledge of no analogous disease, and of no toxæmia comparable to that which follows operation upon people afflicted with hyperthyroidism. It is therefore particularly difficult for the uninitiated to realize how critical is the condition of so many of these patients until, as a demonstration, a death has been experienced.

As so impressively pronounced by Dr. Mayo at his clinic, saturation of the patient with water must be accomplished in one way or another. The surgeon must not accept excuses that water could not be given by mouth because it hurt the patient to swallow, and not by the intestine because the guttatim injections were expelled, unless the patient is uncontrollable; in such event prompt resort to subcutaneous infusion must be had.

Chilling or Freezing the Neck Before and After Operations for Graves' Disease.—It had not occurred to me until the end of June, a few days before leaving town for the summer, that excessive cold applied to the neck in these cases, particularly after operation, might delay the processes of repair and absorption and thus bridge over the period of greatest danger, the two or three days succeeding operation. Its employment was very imperfectly tested in three instances, but in all with beneficial results, it seemed to me, although one of the patients,

desperately ill before operation, did not recover. In no instance, unfortunately did we succeed, with the inadequate appliances at our disposal, in doing much more than slightly cool the surface of the skin. In one case, 36 hours after operation, the pulse which had been steadily rising until it reached 180, dropped 30 beats per minute within one and one half hours of the application of the cold. In another, a good night's sleep, the first in weeks, seemed to be attributable to the application of cold to the neck. It is quite possible that harm rather than good might be done by ineffectually applied ice bags. They might serve as a poultice if, for example, swathed in protecting flannel, or if negligently attended to. The danger of reaction, too, must be constantly borne in mind—the reaction following either a brief or a prolonged use of the cold. Therefore no time should be lost in changing the packs; and ultimately the cold should gradually be withdrawn. I doubt the ability of the rubber ice bag to produce a degree of cold sufficient for the very ill cases; or the non-conducting rubber should, perhaps, be so thin that rents would be hardly avoidable. In some cases a degree of cold low enough almost to freeze the skin might be necessary. Possibly to be considered as a method of treatment for desperately ill cases is an unclosed wound constantly irrigated with water of the desired temperature.

I am convinced that the toxæmia is not simply due to the absorption of thyroid secretion. Otherwise might not the gravest cases of exophthalmic goitre be safely treated by total excision of the thyroid gland? It is my belief that the toxæmia incident to wound healing is badly borne by the subjects of hyperthyroidism. On several occasions, soon after thyroid lobectomy, I have seen prompt and great improvement follow the liberation of a drachm or even a few drops of reddish serum from the wound. Moreover the typical post-operative toxæmia may, it seems, follow operations of other kinds upon patients afflicted with Graves' disease. Absorption takes place continuously during the process of repair, even in wounds which are "dry" and healing throughout by first intention. Thus it

seems to me quite reasonable to hope that something, perhaps much, may be accomplished by the adequate employment of cold. The entire neck fore and back and sides, and from chin to chest might be made so cold in the serious cases as to arrest for a time, more or less completely, the process of absorption and possibly of healing.

Furthermore, if absorption from the wound is, even in a measure, responsible for the toxæmia so badly borne, the area of the wound surfaces must be a factor influencing the result; and, if so, there would be in this an indication for as small a wound as feasible in certain cases. A vertical skin incision to avoid reflection of a flap might be tested and less complete division of the muscles at their attachment to the hyoid bone might suffice for the liberation, in the manner described in this paper of the superior pole. The operation of ultra-ligation might thus be effected through a hole just large enough to permit the delivery of the lateral lobe of the thyroid gland.

TETANY PARATHYREOPRIVA:*

A CASE REPORT, WITH A BRIEF DISCUSSION OF THE DISEASE AND OF THE PARATHYROID GLANDS.

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THE acquisition in recent years of an anatomical knowledge of hitherto unsuspected organs, the parathyroid glands, has engendered much investigation as to the physiological rôle and pathological import of these bodies. Dependent upon such studies, interest has coincidently centered on the subtle question as to the explanation of certain nervous manifestations which attend the removal of these structures in animals. The condition thus artificially produced appears to be of the same nature as a group of symptoms which occasionally occurs in man. These symptoms were first described by Steinheim [1] in 1830, and the name tetany was subsequently given to them by Corvisart.[2] Since then the same clinical picture has been repeatedly noted in association with various conditions of widely different character. For example, it has been seen to occur with severe gastro-intestinal affections, especially dilatation of the stomach, with pregnancy and the puerperal state, with some acute fevers, with various nervous diseases, and after removal of the thyroid gland.

The cause of its occurrence in most of these conditions is not understood. As a sequel, however, to thyroid operations it has been definitely, ascribed to the removal of the parathyroid bodies, and in consequence has been designated by Erdheim [3] tetania parathyreopriva.

Observation of a case which recently came under my care

* Read before the New York Academy of Medicine, May 2, 1907. Through the courtesy of Prof. T. M. Prudden and Prof. J. A. Blake the work for this paper was done in the Pathological and Surgical Research Laboratories of Columbia University.

gave rise to an effort to collocate the clinical features and therapeutic possibilities in this variety of tetany. To do this clearly it seems necessary to supplement such considerations with a review of the history of the subject and of the anatomy, development, and theories as to the physiological rôle of the parathyroid glandules.

Case Report.—The patient, a seamstress by occupation, is a Swiss, thirty-three years of age. She was referred to my service at the French Hospital by Dr. Fellowes Davis, in April, 1906. The significant features of her history are as follows:

In 1903, she had considerable pain in the lower part of the neck and marked dyspnœa and dysphagia. For some time previous to that there had been a large tumor in the region of the left lobe of the thyroid gland. An operation was performed in Bern, Switzerland, and a tumor on the left side of the neck was removed. This was undoubtedly the left lobe of the thyroid. For one year after the operation she was relieved of her symptoms, but during the second year the dyspnœa, dysphagia and swelling returned and increased to such an extent that operation became imperative.

Besides the features mentioned above there was nothing of importance in her history. Though in childhood a number of operations had been performed upon her eyes, the last of which was eighteen years ago, she had always enjoyed good health and had never suffered from any nervous troubles.

Physical Examination.—The woman was thin and pale, her expression anxious, breathing labored, the sternomastoids prominent. There was a slight rounded projection, about one and a half inches in diameter, just above the sternum, and a faint scar of the incision of the former operation could be seen. The mass, which reached beneath the sternum, was firm and nodular and moved with the larynx on swallowing. The examination was otherwise negative.

On March 3, 1906, I operated under ether anæsthesia and exposed the thyroid by a curved incision. In the region of the isthmus there was a round, smooth mass, about two and one-half inches in diameter, which was to a great extent bound down by cicatricial tissue; it extended downward behind the sternum and

compressed the trachea. The left lobe of the thyroid was absent. Before any tissue was removed the right lobe was thoroughly exposed and found to be of normal size, appearance, and consistency. Accordingly, the thyroid gland was clamped at the junction of the isthmus and the right lobe, and cut across as close to the tumor as possible. Before doing this it was found necessary to ligate the inferior thyroid artery which ran close to the tumor. The whole of the right lobe, except a small part which lay close to the isthmus, was left. The wound was closed with drainage.

Postoperative Course.—The healing of the wound was uneventful. On the fourth day after operation, tetanic contractures occurred in both hands, which assumed an attitude similar to that produced by stimulation of the ulnar nerve, an attitude sometimes called the accoucheur's hand, since it is the same as the position taken for making a vaginal examination. Throughout the disease this was the usual contraction of the hands. The spasm was accompanied by cramp-like pains in the hands, and occasional twitching of the facial muscles, with some neuralgic pains in the right side of the face. This condition was present whenever the patient was seen during the next twenty-four hours, when cramps in the feet and calves occured together with forcible plantar flexion of both feet which lasted for about five minutes.

After that for about thirteen months the patient presented the typical clinical features of tetany. Of the symptoms, the most conspicuous were bilateral and symmetrical contractions of the flexor muscles of the hands, wrists, and feet (Figs. I, II and III), as previously described, preceded and accompanied by cramp-like pains in the affected muscles. To these spasms were added at times attacks of more general contractures, occasionally with cyanosis which necessitated the administration of chloroform, attacks of asthmatic breathing, of tetanic spasms of the muscles of the face, jaw, neck and back, slowness and thickness of speech, difficulty in swallowing, but apparently no dullness of mind. The skin and hair seemed unchanged beyond a slight growth of hair on the chin and upper lip. There was for several weeks marked edema of the left wrist and hand, and redness over the knuckles of this hand. Chvostek's and Trousseau's signs were present and typical almost all of the time. Thus, the facial muscles, as

a rule, contracted rapidly to mechanical irritation by tapping over the facial nerve; and by steady pressure on the nerves and vessels of the arm the usual contracture of the hand was brought on in about one-half to three minutes, sometimes with distinct fibrillary twitching over the thenar eminence. In this test, cramp-like pains regularly preceded the spasm which developed gradually and not suddenly. Contractures also resulted from making the sciatic nerve tense by holding the patient in a sitting position, so that the trunk and thighs were flexed beyond a right angle, with the legs extended; or by putting the nerves of the brachial plexus on the stretch by elevating the arm above the head with the forearm extended (extreme abduction). Figs. IV and V.) The contracted muscles were always board-like to the touch. Unfortunately, tests with the galvanic current were not made; but Dr. J. A. Booth reported on February 8, that with the faradic "even mild currents brought on tetanic contractions in both upper and lower extremities, showing a decided increased electrical excitability."

The above symptoms occurred in attacks at variable intervals. During the first six weeks and the last three months of the disease, there were from one to five attacks almost every day. The duration was from several minutes to several hours. During the intervening seven months, when the patient was not in the hospital, they were much less frequent, but prevented her from working.

About five weeks ago the attacks of typical tetanic spasms gradually ceased; the other tetanic symptoms also gradually disappeared, and Chvostek's, Trousseau's, and the other two tests mentioned above, became less marked, and now elicit no response. Moreover, the electrical tests made by Dr. Booth on April 23, showed only slightly increased galvanic irritability in nerves and muscles, the most marked being in the ulnar nerve ("Ca Cc>An Cc, 3 Ma").

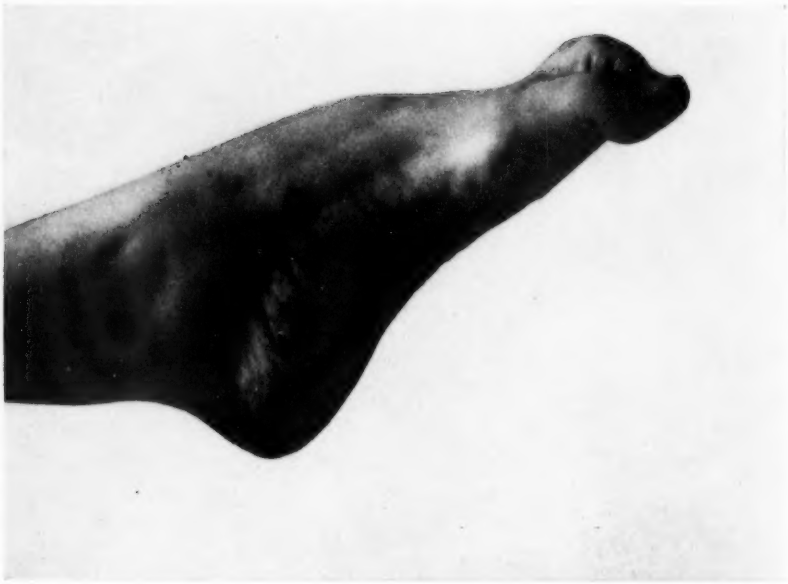
Hysterical symptoms of various kinds have, however, become marked and are now striking. This is not surprising considering the prolonged sickness and the frequent use of hypnotics and other drugs. This condition, however, is improving under the care of Dr. Booth.

As regards treatment, the following were tried: various thyroid and parathyroid preparations by mouth and hypoderm-

FIG. 1.

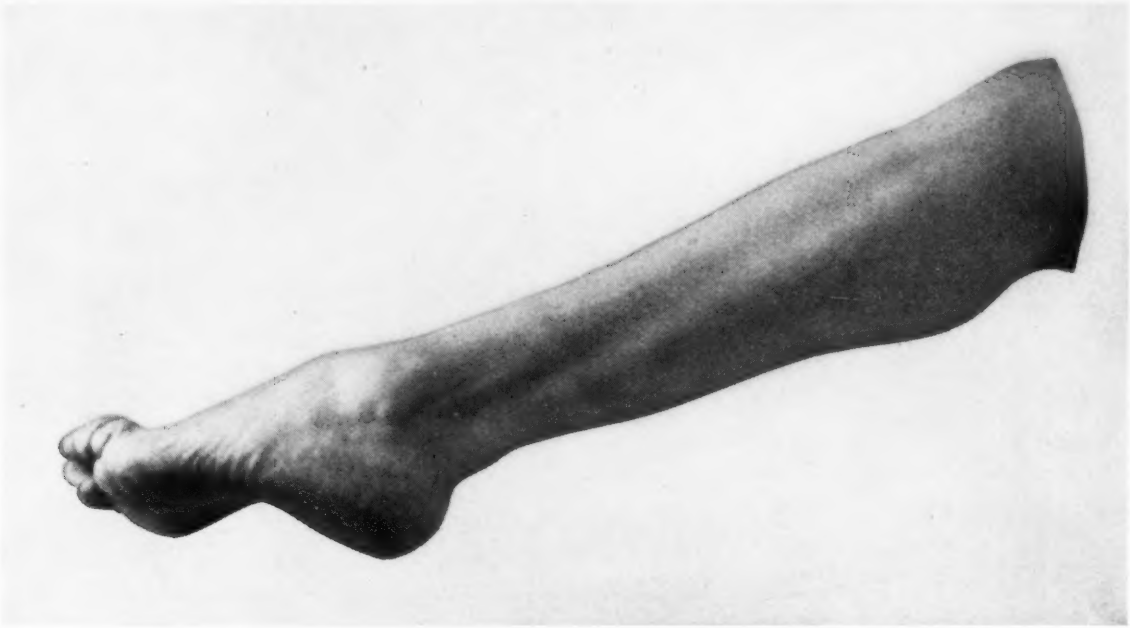
Tetanic spasm, showing flexion of wrist.

FIG. II.



Tetanic spasm, showing plantar flexion of foot and toes.

FIG. III.



Tetanic spasm showing contraction of muscles of calf.

FIG. IV A.

Method of producing a tetanic spasm in feet by stretching the sciatic nerve by means of forcible flexion of trunk on thighs. Taken immediately on sitting up, before occurrence of spasm.

FIG. IV B.

Method of producing a tetanic spasm in feet by stretching the sciatic nerve by means of forcible flexion of trunk on thighs. Taken 1½ minutes later, showing onset of spasm.

FIG. V.

Method of producing tetanic spasm of hand by stretching the brachial plexus by means of forcible abduction of arm, showing accoucheur's hand.

ically. The parathyroid material was supplied by Prof. Vassale, of Modena, by Dr. Beebe, of New York, and by Armour and Co. One saline infusion of twenty-four ounces was given, and five parathyroids were implanted subcutaneously. These were removed aseptically immediately after death from three accident cases, put at once into ascitic fluid, and implanted as soon as possible. Under general anæsthesia the implantations were made into the abdominal wall and the lobe of the ear. In the latter case a deep incision was made along the lower free margin of the lobe so as to divide it into two lips. Cocaine was not used on account of the disadvantage which might result from the infiltration of the tissues. The parathyroids, while in the ascitic fluid, were cut so as to expose two or more raw surfaces; the technique differed in this respect according to the size of the gland. The lobe of the ear seemed to present a particularly favorable site for the implantation because a perfect and permanent opposition of the implanted parathyroid and the two surfaces of the wound was readily obtained by gentle pressure produced by an appropriate dressing. All the wounds healed by primary union. The first two implantations were made on March 1; in this case the operation was finished ninety minutes after the death of the patient from whom the tissues were taken. The other three implantations were made on April 17.

The improvement which occurred about one month ago,* that is, the gradual disappearance of the true symptoms of tetany, was coincident with the repeated administration of Beebe's nucleo-proteid in large doses by hypodermic, and occurred from four to six weeks after the first implantation. No effect could be attributed to other therapeutic measures.

Historical.†—Operations for goiter were uncommon until about 1877; but since then, due largely to the impulse of Billroth and Kocher, they have progressively increased in frequency. The occurrence of tetany after such operations was first recognized by Weiss [6] in 1880. About three years later, Kocher [7] and Reverdin [8] called attention to the condition since known as

* This paper was read May 2, 1907.

† Since exhaustive histories have been published several times, only a résumé is given here, and the reader is referred to such articles as those by Erdheim,[3] Jeandelize,[4] and Welsh,[5] for a more detailed account.

cachexia strumipriva, and this was shown by Kocher to be a frequent sequel to complete thyroidectomy. The two diseases, tetany and cachexia strumipriva, were regarded for a considerable time simply as different phases of one condition which was supposed to be dependent upon insufficiency of the obscure funtion of the thyroid gland.

The above clinical contributions awakened a new interest in the study of the thyroid by animal experimentation, which had been carried on intermittently ever since the early thirties [9] of the last century, but with indefinite and contradictory results.

As a result, Schiff,[10] in 1884, clearly showed that certain animals, notably cats and dogs, regularly succumb to complete removal of the thyroid gland except in isolated cases which were explained on the supposition that the thyroid function was then carried on by aberrant or accessory thyroids.

In consequence of the dire effects which were thus noticed experimentally as well as clinically after complete thyroidectomy, it became a surgical mandate that part of the organ should be spared in goiter operations. This precept, which was fathered by Kocher,[11] has prevailed up to the present time and its practice accounts for the relative infrequency of postoperative tetany and cachexia strumipriva.

In the results of animal experimentation a perplexing inconsistency prevailed. Whereas total thyroidectomy in dogs, cats, and carnivora in general, was regularly followed by fatal tetany, in contrast to these animals, rabbits and other herbivora regularly survived the operation with no evidence of tetany, but with the development of the slower cachexia strumipriva.

The peculiar difference in the reactions of these two classes of animals to the removal of the thyroid gland was the crux which for a long time defied explanation and prevented further progress. Its ultimate solution, however, furnished the clew which resulted in rapid advances leading up to our present knowledge of the subject. The credit for this all-important step is due to Gley [12] who in 1891 called attention to the existence in the rabbit of two bodies entirely separated from the thyroid, the external parathyroids. He demonstrated that in this animal the removal of these together with the thyroid produced the same effects as complete thyroidectomy in other animals. His conclusions may be summarized as follows:

1. The removal of the thyroid alone (in the rabbit or dog), leaving the two external parathyroids, causes no tetany.

2. The removal of the two external parathyroids in the same species of animals, also causes no tetany.

3. The removal of the thyroid and the two parathyroids, at the same time or in two stages, results in tetany.

He explained incorrectly the negative effect of removing the thyroid alone (1, supra) by the assumption that the parathryoids which were left acted vicariously for the thryoid. Moreover, since he did not recognize the existence of the internal parathyroids, the negative results following removal of the two external ones suggested to him nothing significant.

Attention should be called to the fact that Sandstroem [13] in 1880, eleven years before Gley's contribution, had recognized the parathyroids in man, and had described their gross anatomy and histology minutely and accurately. Apparently little notice was taken of his report, and certainly it failed to stimulate scientific research. However, the name "glandulæ parathyroideæ" which he applied to the organs, has been generally adopted.

While a new theory was suggested by Moussu,[14] to the effect that the simultaneous ablation of the thyroid and parathyroids might possibly suppress two functions instead of one, the first practical step towards ascribing to the parathyroids an independent potency resulted from the work of Vassale and Generali [15] which was published in 1896. They demonstrated that the removal of the four parathyroids, the thyroid being preserved, led to fatal tetany; while no tetany resulted from the removal of the thyroid if the parathyroids were left. These conclusions were based upon the following striking experiments:

Ten cats; total parathyroidectomy; nine dead before 11th day. In all there were characteristic symptoms of tetany.

Nine dogs; total parathyroidectomy; all dead before the 9th day. In these animals the symptoms were analogous to those of complete thyro-parathyroidectomy. Every effort was made to exclude complications, such as injuries to nerves or to the thyroid as possible causes of the fatal results.

It has been urged by numerous experimenters, among whom are Biedl,[16] Walbaum,[17] Vassale and Generali, that the intensity of tetany parathyreopriva stands roughly in inverse ratio to the number of healthy parathyroids retained by the animal. Thus,

in a cat the removal of three parathyroids has been said to result generally in fatal tetany; of two, in lighter tetany; of one, in no tetany. But this rule is certainly far from absolute, for sometimes the presence of one parathyroid is sufficient to prevent the symptoms of tetany, while in other cases, two of the organs are necessary (Erdheim). The difficulty of formulating any exact deductions in regard to this phase of the subject is further increased by the fact that besides frequent variations in animals of the same species, there is a constant and marked difference in the reaction of different species to partial or complete parathyroidectomy, in respect to the rapidity of the onset and the intensity of the symptoms.

In 1903, Jeandelize, in an exhaustive treatise, reviewed and amplified the whole subject. The following summary from his work is a fair indication of the general attitude at that date.

1. The thyroid and parathyroids are different organs.

2. The results of ablation of the two are not the same.

3. Physiologically, the two organs are dependent upon one another, yet neither can assume the functions of both.

In elaborating the effects of ablation of these organs he calls attention to the fact that thyroidectomy alone does not cause the grave troubles of parathyroidectomy, but instead, especially in young animals, gives rise to troubles of nutrition. The animals remain undersized, their behavior is altered and sluggish, the skin becomes thick and edematous, and the hair becomes coarse. The onset of the change is less than a month after the operation.

On the other hand, he states, parathyroidectomy produces a more rapid onset of symptoms, which are briefly, fibrillary twitchings, tremors, local or general contractions (tonic or clonic), convulsions, dyspnœa, tachycardia, ptyalism, thirst, vomiting, diarrhœa, general weakness and prostration.

He therefore concludes that as a result of insufficiency of the thyroid there occur nutritional disturbances, whereas insufficiency of the parathyroid produces acute convulsive troubles. This, he says, is proved in several species of animals and is probably true for all vertebrates.

In consequence, it was assumed that operative myxedema, which is a nutritional disturbance, is due to removal of the thyroid, and tetany, which is a convulsive trouble, to removal of the parathyroids. Under such an assumption these two con-

ditions necessarily came to be regarded as radically different, a transition from one to the other being out of the question.

Erdheim has recently by clinical and experimental observations further elaborated the evidence of the potentiality of the parathyroids. After partial or total destruction of the parathyroids in rats, with the minimum of injury to the thyroid, he studied the symptom complex of the resulting tetany which occurred in all the cases of total parathyroidectomy. In the animals presenting tetany, by systematic serial microscopic sections of all the organs of the neck, he demonstrated the presence of the thyroid and absence of parathyroid, and thus established the fact that the lesion in every case was purely parathyreopriva.

Although individual differences were marked in his animals, tetany began, as a rule, several hours after operation, and reached its height usually in the first twenty-four hours in the form of epileptiform convulsions. The condition then passed into a chronic state. In the study of the symptom complex due to parathyroidectomy exclusively, besides demonstrating the regular occurrence of a typical tetany, Erdheim also verified the occurrence of regular nutritive changes, notably very excessive growth of the lower incisors. But the association with tetany of some trophic disturbances resembling those observed in cachexia strumipriva was not regarded as a justification for the conclusion that the two conditions are of identical origin.

Erdheim's studies of three cases of human tetany are remarkably significant. In each a partial thyroidectomy was performed for goiter. Unquestionably tetany developed shortly after the operation and death followed on the 131st, 5th, and 17th days. Very complete serial microscopic sections of the neck organs showed in each case the presence of considerable well preserved thyroid tissue, whereas in the first case none of the four usual parathyroids were found, and only two very small accessory parathyroids which lay in the thymus; in the second case only one parathyroid was recognizable, and that was practically entirely necrotic; in the third case not one of the regular four, nor even an accessory organ was found.

A review of all cases of tetany which have been reported as occurring after strumectomy would prove unfruitful. Only a small number are of practical interest in this connection, namely, partial thyroidectomies which permit definite conclusions as to

the involvement of the parathyroids in the extirpation. Pineles [18] compiled thirteen cases of this kind. Of these, there were six cases of extirpation of both lateral lobes, four cases of preservation of the upper portion of one lateral lobe, three cases of extirpation of a lateral lobe with the isthmus. As a result he pointed out that tetany follows partial thyroidectomy most frequently in those cases where extirpation of, or injury to, the parathyroids is most likely to occur; and consequently that tetany is most likely to follow those cases in which only the isthmus or upper part of a lateral lobe is left.

It seems then to have been proven by a long series of careful experiments, strengthened recently by the significant findings of Erdheim and Pineles in man, that tetany following goiter operations is due to the removal of the parathyroid glandules. Nevertheless, this attributes such marked potency to these little organs that, not unnaturally, there are still some observers who are skeptical as to the truth of the assumption, and among them are competent men who have weighed carefully all sides of the question. The explanation of this divergence of opinion lies in the fact that besides such apparently conclusive results as those described above, there have been numerous other investigations, the outcomes of which have not been uniform or positive. For example, even recently, Vincent and Jolly [19] have found that "removal of all four parathyroids was not necessarily fatal," and they "were unable to confirm some other statements which are very commonly accepted" on this subject. Further, Vincent wrote that "the question of the extreme importance of the parathyroids can not yet be considered as settled." Moreover, Caro,[20] although familiar with the extensive work of Pineles, has quite recently expressed the opinion that there is no reason for abandoning the former interpretation that tetany is an acute manifestation of the loss of thyroid (not parathyroid) substance. Animal experimentation has failed to convince him of the importance of the parathyroids. He states, moreover, that in goiter cases, the parathyroids are sometimes found to consist simply of atrophic and barely distinguishable lamellæ closely applied to the capsule, and he arrives at the conclusion that in Erdheim's three cases the dependence of the tetany upon the suppression of the parathyroids is by no means proven. However, it is fair to state that almost all observers at the present time regard tetany

following goiter operations as the direct result of the absence of the parathyroid function.

CASES OF TETANY PARATHYREOPRIVA, FOLLOWING PARTIAL THYROIDECTOMY, COLLECTED BY PINELES,[18] WITH LATER ADDITIONS.

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Wien. klin. Woch., 1906, p. 780.
Reichel, (2 cases) Münch. med. Woch., 1905, p. 2012.
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Monnier, E., Beit. z. klin. Chir., Bd. liv, 1907, p. 63.

ANATOMY OF THE PARATHYROID BODIES IN THE HUMAN SUBJECT.*

In man parathyroid bodies are constantly present; the number varies. Exact enumeration in an individual case is difficult for two reasons; first, their small size and variable position render it an easy matter to overlook one or more of the bodies; second, various tissues may be mistaken for a parathyroid, especially lymph nodes, hæmolymph nodes, accessory thyroids, thymus rests, and fat. Microscopic examination alone can exclude these tissues.

Berkeley,[21] as a result of about one hundred and twenty-five autopsies, concluded " that while the number four seems

* For technique of dissection cf. Berkeley[21] or Petersen.[22]

to satisfy the demands of anatomical symmetry, this number is often diminished by one or more" and occasionally increased. He apparently found on an average about two and a half parathyroids per person. Most observers have reported smaller averages, but Verebely [22] found four parathyroids 108 times in 138 autopsies. In our own dissections,† the last sixteen resulted in an average of 2.9 per person. In all of these one-half of every suspected tissue was removed and examined microscopically. The other half was left in situ for further reference; a lettered drawing of each specimen facilitated identification of the sections.

The occurrence of the glands in pairs may properly be considered the typical arrangement, a superior and an inferior body being present on each side. Judging from our own dissections and the descriptions of Verebely, Thompson [24] and earlier writers, the following seem to be the most frequent situations, and correspond closely to the drawing (Fig. VI).

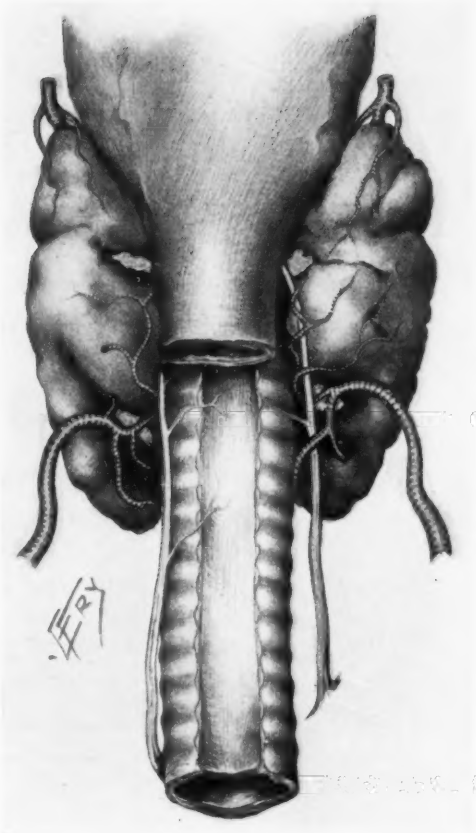
The superior, the more constant in position, lies close to the thyroid in the middle third of its posterior border, approximately on the level of the lower border of the cricoid cartilage (Welsh [5]). It lies in a plane posterior and external to the terminal branches of the inferior thyroid artery and recurrent laryngeal nerve. On the left side the gland is frequently further posterior than on the right.

The inferior, often intimately associated with the thymus (Verebely), lies at or below the inferior pole of the thyroid or on the posterior aspect of the lower third, in which case it is frequently found anterior to the recurrent laryngeal nerve and inferior thyroid artery, close to the thyroid gland at the entrance of the lower twigs of the artery.

Variations from these anatomical positions are frequent. The most striking which we have found was the presence of a large parathyroid on the anterior surface of the isthmus. As common variations in position may be mentioned the tip of the lateral lobe of the thyroid or even above this; anywhere on or

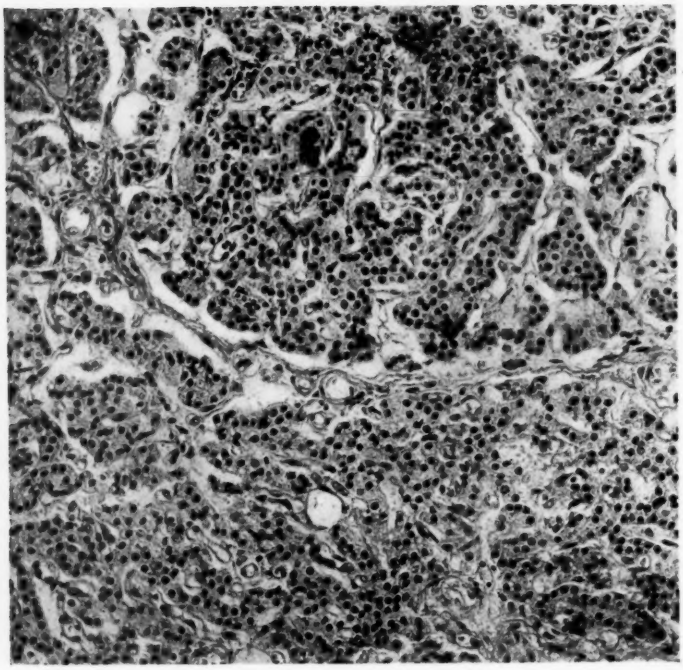
† These were done with the aid of G. C. Whitney, of the Third Year Class of the College of Physicians and Surgeons.

FIG. VI.



The parathyroid bodies, showing situations in which they are sometimes found.

FIG. VIII.

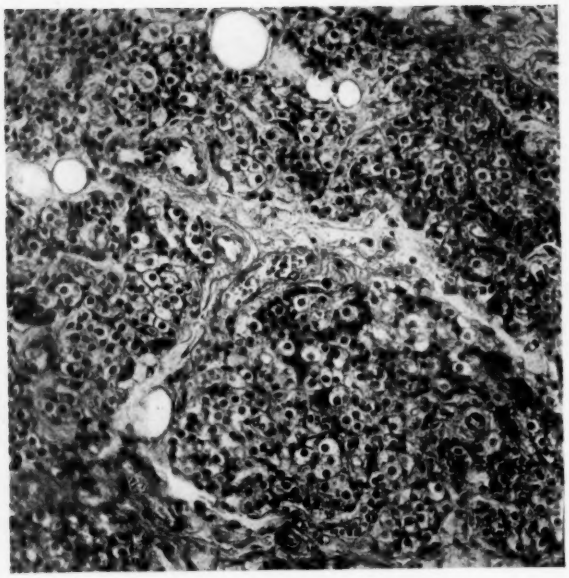


Distribution of cells in strands and groups. Colloid is present in several places. A.

FIG. IX.

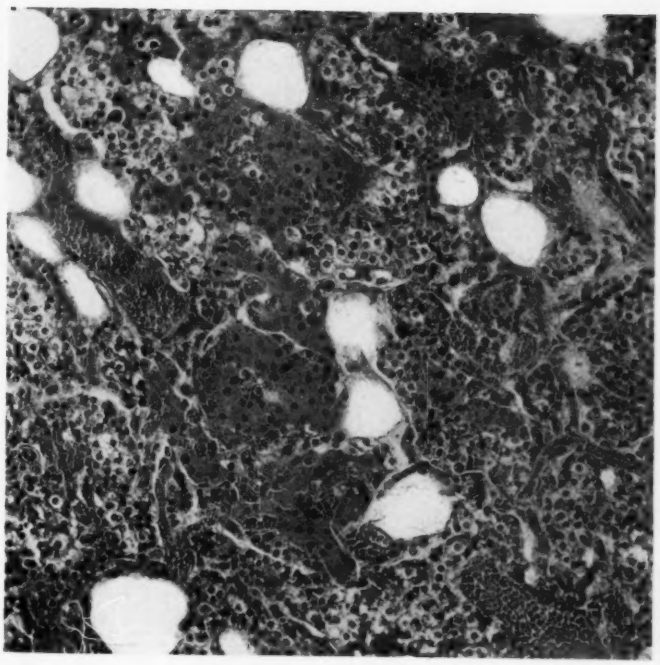
Showing an acinus with lumen.

FIG. X.



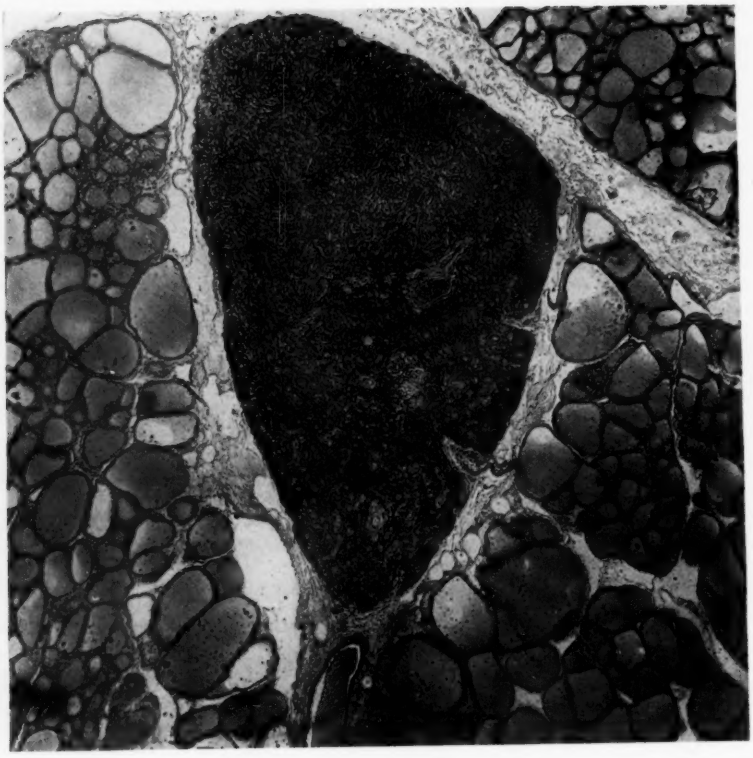
Principal cells.

FIG. XI.



Masses of oxyphile cells.

FIG. XII.



Parathyroid of a dog.

near the posterior border. These sites, however, do not limit the possibilities.

Accessory organs, that is, small accumulations of characteristic parathyroid cells, have been found not infrequently below the thyroid, especially within the thymus.*

While in most cases the glands lie embedded in fat outside of the thyroid, the position of one or more may be beneath its capsule, but only very rarely embedded in its substance (Verebely). Each parathyroid is completely invested with a thin fibrous capsule under which a fine anastomosis can be seen. The size of the organ varies from about 3 mm. to 15 mm., the average being about 6 x 4 x 2 mm. (Berkeley). The bodies are usually somewhat flattened, and may be of various shapes, but especially round, oval, or reniform. Occasionally a parathyroid is subdivided into two distinct parts. The color is a brown red or a reddish yellow. Often a glandule of regular outline presents a relatively large segment of fat. This is said to occur most often in advanced age.

The blood supply of the gland is derived from branches of the superior and inferior thyroid arteries, particularly the former.

Histologically (Figs. VIII–XII) the organ consists of a mass of cells invested with a thin fibrous capsule from which occasional irregular processes reach inward. The gland has a reticular stroma, and is as a rule strikingly vascular, presenting numerous large capillaries. Frequently fat is present, both as an infiltration of the stroma and as a cellular metamorphosis.[26] The amount is subject to very wide differences and to this is largely due the variable color of the gland. Especially in advanced life a considerable part of the gland may be replaced by fat. The distribution of the cells varies greatly. They may form an extensive cell mass with only occasional interruptions by vessels and fibrous strands, or they may be broken up by vessels and connective tissue so as to form clusters of lobules or net-like trabeculæ. Occasionally there is an alveolar group-

* They have also recently been described as occurring within the thyroid (Getzowa[28]).

ing of cuboidal or somewhat cylindrical cells with basal nuclei. These at times surround a lumen filled with colloid, which is said by Richardson [27] to be retrograde or degenerative material, and not a higher stage of glandular development. Intracellular and intercellular accumulations of colloid also occasionally occur, while glycogen has been demonstrated as a cell inclusion (Petersen).

The cell grouping rarely comprises one alone of the above structural types; as a rule there is a combination of the varieties, the divergencies presented by individual glands in this respect being very wide. The cells themselves are mostly polygonal, sometimes round or cuboidal. They are classified by Welsh [5] as of two distinct types:

Type I. "Principal cells." These are by far the more numerous. The cell body is relatively small and is either feebly stained with basic aniline dyes, or is clear and colorless. The cells then seemingly consist only of nucleus and membrane which takes a deep eosin stain. We have noted that some of the cells which belong to this group sometimes present an irregular stained peripheral zone and a clear cytoplasm immediately around the nucleus. The variations in the relative width of the clear and the stained zones suggest that under certain conditions the cytoplasm of the clear cells takes on a stain which acts first near the periphery and then progressively toward the nucleus until the whole cell body may be stained.* The nucleus with open chromatin network is large, pale, often ovoid, and frequently, eccentrically situated. The distribution of these cells conforms to the general description already given.

Type II. "Oxyphile cells." These have a relatively large, finely granular body, the granules of which stain deeply with eosin. The nucleus with closely arranged chromatin is small, and round, and takes a deep stain. Compact masses of these cells frequently occur, especially immediately beneath the capsule. They are also distributed as anastomosing columns and as single cells or small groups scattered among the principal cells; lastly, in rare cases, acini with colloid are met with.

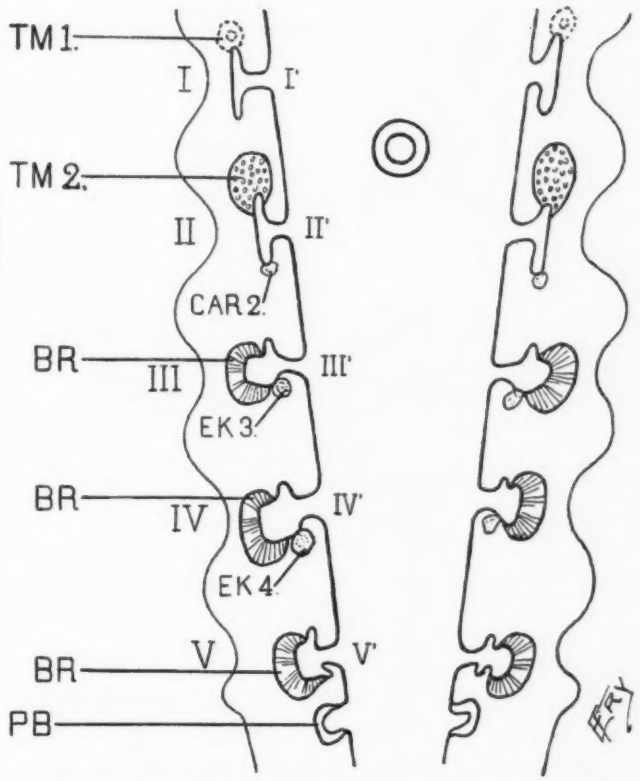
Petersen [23] adds a third type. His Types I and III are respectively the same as Types I and II of Welsh. He describes Type II as not characteristic. The cells are smaller than in I; there is no sharp boundary to the cells, of which the granular protoplasmic body stains deeply with eosin; in places

* Since the above was written, Getzowa has reported similar findings and has gone so far as to subdivide the group into "wasserhelle" or clear, and "rosarote" or pink cells.

the cells are so small that nothing is seen but a complex of deeply stained nuclei. He states that all possible intervening forms occur between Types I and II, and suggests that the organ is a glandular one, and that Type I represents the functionating condition.

In studying parathyroids microscopically, the three varieties of cells can easily be recognized. Further, careful exam-

FIG. XIII.



Diagramatic scheme of branchial clefts from Anura. (Modified from Maurer.)

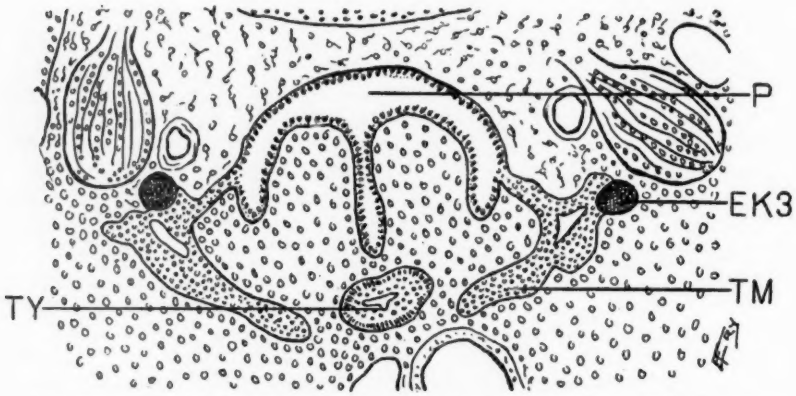
ination enables the observer to trace the cells in some glands from the clear ones of Type I through the above described granular condition to the small granular cells of Type II of Petersen. With more difficulty, gradations also may be traced

from the latter to the large granular cells (Type II, Welsh; Type III, Petersen), where these occur singly or in small groups; but the line of demarcation at the edge of the large groups is sharply drawn. Following the analogy of the salivary and other glands the question naturally suggests itself as to whether the granular cells are not the functionating and the clear cells the resting condition of the cells.†

EMBRYOLOGY.

It is necessary to touch briefly on the embryology of the parathyroids in order to establish their developmental independence of the thyroid.

FIG. XIV.



Transverse section of embryo of echidna, level of third branchial cleft. (Modified from Maurer.)

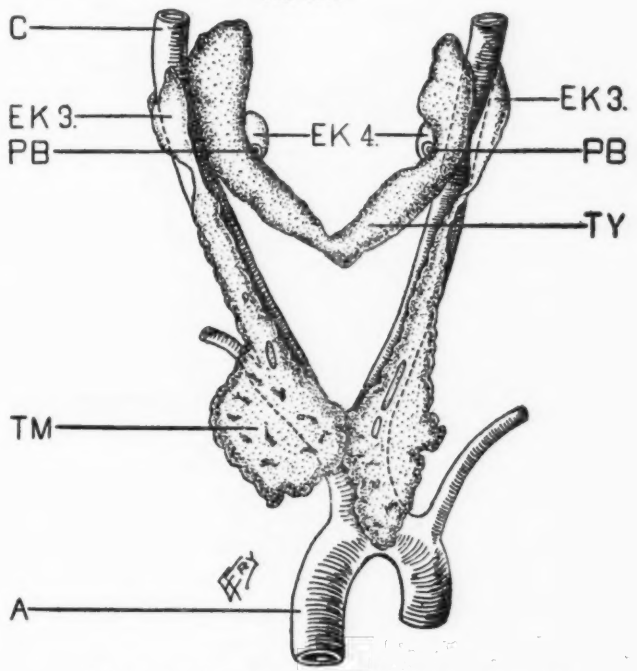
The parathyroids or "epithelial bodies" (Kohn[28]) are branchial cleft derivatives. In man and most mammals they develop from the third and fourth branchial clefts of each side as masses of compact epithelial cells which are in no way connected with the thyroid (Fig. XIV). Two on each side is the usual arrangement, though anomalies are not infrequent.

The third pharyngeal pouch with its derivatives, the thymus and the parathyroid body, becomes separated from the

† Getzowa[25] has recently expressed a similar view.

pharynx. This parathyroid body later comes into relation with the thyroid from the side and forms the inferior parathyroid or outer "epithelial body" (Kohn) (Figs. XV and XVI, EK 3). When the fourth pouch becomes separated, its derivatives, the parathyroid, thymus, and post-branchial body, are primarily connected. The post-branchial body and the superior parathyroid or "inner" epithelial body (Fig. XV and

FIG. XV.



Embryo of rabbit, 16 m.m. long. (Modified from Verdun.)

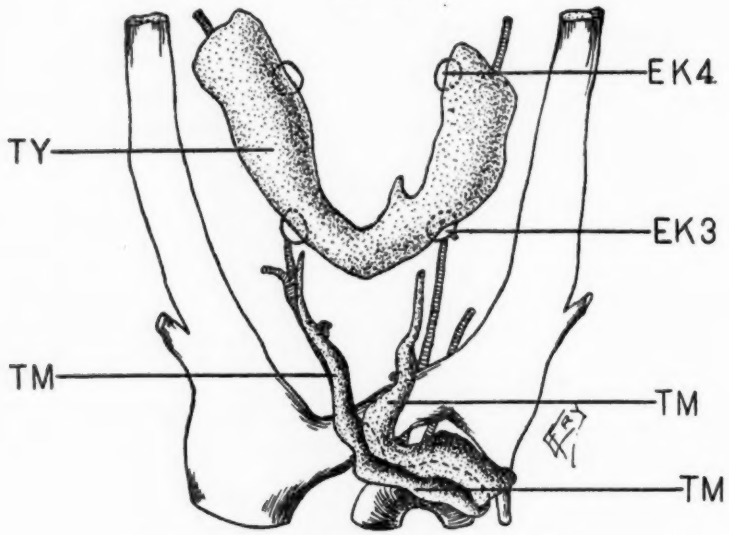
XVI, Ek 4) become annexed to the thyroid only secondarily in the course of development. There is no proof of the assumption that the parathyroids are embryonal thyroid tissue and that they may under certain conditions develop into the mature tissue of that gland. The relation of these bodies to the thyroid must, on the basis of our present knowledge, be regarded as purely topographical.*

* Sophia Getzowa in a very elaborate article has recently advanced

PHYSIOLOGICAL AND PATHOLOGICAL CONSIDERATIONS.

If we accept the view that the parathyroids have a function in part or altogether independent of the thyroid, there are certain hypotheses and experimental results which from a physiological standpoint are suggestive and offer a basis for further investigation.

FIG. XVI.



Human embryo 29 m.m. long. (Modified from Verdun.)

TY. Thyroid.	I-V Branchial clefts, outer aspect.
TM. Thymus.	I'-V' Branchial clefts, inner aspects.
Car 2 Carotid gland.	P. Pharnyx.
EK 3 Parathyroid of third cleft.	A. Aorta.
EK 4 Parathyroid of fourth cleft.	C. Carotid.
PB. Post branchial body.	BR. Branchial rests.

The hypothesis has been advanced by MacCallum,[29] Frommer,[30] Lundborg,[31] and others, that the parathyroids have an antitoxic action, the suppression of which results in the tetany reaction. By this hypothesis tetany parathyreopriva would be

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the hypothesis that there may be an independent third parathyroid developed from the fifth branchial cleft. In this way she would explain the occasional occurrence of parathyroid tissue within the thyroid gland in cases in which the extrathyroidal superior parathyroids are also present.

explained as an auto-intoxication. In support of this view is the fact brought out by MacCallum, that the disease in animals is temporarily relieved by bleeding and injection of salt solution into the veins; this, he thought, demonstrated the presence of a circulating toxin. The transmission of tetany to a healthy animal by transfusion of blood from one affected with the disease, although claimed by some as possible, can not be accepted as proved.

If the above hypothesis is accepted, and it seems the most plausible one yet advanced, it may fairly be assumed that whereas the thyroid secretes a substance which is necessary for metabolism, the chief function of the parathyroid is to prevent the action of certain toxic substances regularly present in the circulation.

Attempts to ascribe the etiology of all forms of tetany and even of certain allied diseases, as paralysis agitans, to an imperfect functional activity of the parathyroid glands, have not yet been successful. Nevertheless, Pineles [32] assumes the existence of a common etiology for all forms of tetany. He inclines to the belief that further research will trace the unopposed action of the tetanic toxin in all forms of tetany to a depressed functional state of the parathyroids. Chvostek [33] also expresses the view that all varieties of tetany are dependent upon the parathyroid bodies. His observations of tetany, apart from that following goiter operations, led him to believe that the essential feature in the etiology is a functional disturbance of the parathyroid glands so that they are unable to adapt themselves to various changes. It is due to this susceptible condition, he thinks, that menstruation, pregnancy, infectious diseases, etc., are prone to produce the tetany reaction.

The variety of food and the state of fullness or emptiness of the intestinal tract are said to have but little influence on the course of tetany (MacCallum).[34] Whether the iodin contained in the organ plays an important role is not known.

In regard to the nervous phenomena of tetany no conclusive explanation has as yet been offered.

Symptoms.—According to v. Frankl Hochwart,[35] with

whose descriptions of the disease the following account conforms, tetany parathyreopriva is characterized by certain very striking symptoms which render it practically unmistakable. The most conspicuous of these are intermittent tonic spasms of the voluntary muscles, those of the extremities being most affected. A salient feature is the exclusive involvement of the flexor groups of muscles. Intercurrent contractures of the facial muscles are relatively rare, and the muscles of the chest, back and abdomen participate in exceptional cases only. The tetanic spasms are usually preceded by certain prodromata which persist for a variable period before the onset of the attack. These include headache, sensations of weakness or prostration, more or less rigidity of the limbs, radiating pains and clonic twitchings. The contractions usually begin in the hands, and subsequently involve the feet; less often the feet are affected coincidently or independently. The spasms are almost always symmetrical and bilateral. As a rule, two or more of the fingers are flexed and the thumbs are forcibly adducted, sometimes tightly clasped by the contracting digits. In fifty per cent. of the cases, the wrist also becomes flexed, while flexion of the forearm with adduction of the arm to the trunk occurs infrequently. Exceptionally, the fingers are held wide apart, the terminal phalanges alone being flexed. The feet, when involved, take the position of pes equinus or equinovarus, as a result of contraction of the muscles of the calf. In the contractions of tetany, the affected muscles become very hard to the touch and oppose a powerful resistance to attempts at passive relaxation. Should this prove successful the tetanic attitude is at once resumed when the traction diminishes. Fibrillary twitchings are sometimes visible in the contracted muscles. The duration of an attack may not exceed a few minutes; or the attack may last for a number of hours; but it rarely persists as long as forty-eight hours. The termination of a tetanic spasm is frequently preceded by symptoms resembling those observed at the onset.

While there may be a free interval of days or weeks between the attacks, unfortunately this is far from being the rule.

There are generally several attacks in the course of the day, whereas the patient's rest at night is unbroken. In the severest cases one attack follows another with alarming rapidity.

Trousseau assumes three distinct degrees of tetany based upon the distribution of the spasms: first, a mild form, affecting the peripheral muscles only; some of these attacks may even be limited to the hands: second, a moderate form, with involvement of the facial, abdominal and trunk muscles: third, a severe form, extending to the involuntary muscles.

Besides the attacks of spasms there are other manifestations of the disease. Certain disturbances of sensation are regularly present, especially pain, which is a constant concomitant of the spasms. Hyperesthesia, paresthesia, or anæsthesia may also be noted. Temporary redness and edema are not infrequently observed over the joints. Trophic and secretory anomalies, such as sweating, loss of hair, and changes in the nails, are not very uncommon.

Of particular significance as bearing on the diagnosis are the tests of Chvostek, Trousseau, and Erb. In two-thirds of all cases of tetany it is possible to demonstrate Trousseau's phenomenon. The symptom consists in the occurrence of a tetanic spasm in a limb as the result of compression of its main vessels and nerve trunks. By the animal experiments of Frankl Hochwart and Kashida, this phenomenon has been shown to depend upon stimulation of the nerves.

Chvostek pointed out the facial phenomenon which can be elicited in tetanic patients by gently tapping over the area of distribution of the facial nerve. The resulting short twitchings are known as Chvostek's symptom, which is especially valuable by reason of the simple technique required for its demonstration.

Erb called attention to the fact that electric hyperexcitability of the motor nerves is regularly present in these cases. There is a marked increase of galvanic irritability, especially in the ulnar nerves; whereas an increased reaction to the faradic current is far less constant. The value of the two tests, dependent upon stretching the nerves of the

brachial plexus and the sciatic nerve, which were so striking in our case, can not be estimated properly until repeated trials have been made in further cases.

The tendon reflexes are normal or increased. A certain number of cases, too numerous to be interpreted as an accidental coincidence, present a combination of tetany with typical epileptic seizures. These symptoms have sometimes been observed after thyroidectomy in individuals previously free from nervous symptoms; and a possible connection between epilepsy and tetany has accordingly been suggested. Certain authors also include among the symptoms of tetany the hysterical attacks which are ocasionally present (cf. Frankl Hochwart).

The course of tetany following thyroidectomy has been divided by Frankl Hochwart into three classes: first, cases characterized by onset soon after operation, severe course, and fatal outcome; second, cases in which the symptoms appear soon after the operation but subside after a variable time and are followed by recovery; third, cases in which the patients live and symptoms of myxedema become associated in variable degree with those of tetany.

Diagnosis.—In regard to the diagnosis of tetany, Frankl Hochwart states that it is a simple matter and that there is only one condition, namely, hysteria, which may give rise to symptoms that are strikingly suggestive of those of tetany. But, he says, it will not do on that account to designate tetany or certain of its varieties as a manifestation of hysteria, for there are many features of tetany which can scarcely have anything in common with hysteria. Although he believes imitation of tetany to be uncommon, one can not overlook the possibility of imitation of the symptoms particularly after the tetany has run its course. Such was Minor's [36] explanation of a case observed by him.

Tetany, according to Frankl Hochwart, is at once suggested in the case of individuals who have recently undergone an extirpation of the thyroid gland. He emphasizes particularly the importance of Trousseau's sign as a differentiating test. It is unquestionable that responses can be obtained by

pressure in hysteria and other conditions, which may be readily mistaken for Trousseau's sign (Curschmann[37]). But in a given case, Frankl Hochwart says, the differential diagnosis should be based upon the sudden appearance of spasms as the result of pressure in hysteria, whereas in tetany tonic rigidity is very gradually induced by pressure. He goes so far as to say that in a considerable number of hysterical patients he never succeeded in producing anything akin to Trousseau's phenomenon.

The marked galvanic hyperexcitability of the motor nerves and especially of the ulnar nerves is an important feature for diagnosis. But whether its absence should be regarded as conclusive in ruling out the disease is questionable. Weiss[38] reported one case among thirteen cases of tetany examined by him, in which there was no hyperexcitability. Frankl Hochwart says that he observed a similar case but did not regard it as conclusive because it happened that the ulnar nerve was not tested in this particular patient. Recently, he says, a woman came under his observation who he knew had suffered for years from tetany strumipriva, and had generally presented a very marked galvanic hyperexcitability of the nerves. This time it was not distinctly increased and at best could be designated as rather "high."

Treatment.—Much experimental work has been done on this important phase of the subject. There is, however, considerable confliction in the results reported. This is not surprising since the course of the disease in animals is so irregular as to render it extremely difficult to estimate the effect of treatment. Even without treatment, some animals which present profound manifestations of tetany a few hours after operation, pass, after one or more such attacks, into a chronic condition and live for days, in contrast to others in which the first attack proves fatal.

Attention was naturally first directed to the administration by mouth of thyroid and parathyroid glands and their products. Hoffmann,[39] Levy-Dorn[40] and Westphal[41] and many others have reported improvement of the symptoms of

tetany in man after feeding thyroid gland or its derivatives. Most observers, however, disclaim any favorable results with exclusive thyroid therapy, and Loewenthal and Wiebrecht [42] ascribed the apparent effects of thyroid feeding to the admixture of parathyroids. Yet it does not appear to have been proven that either mixed thyroid and parathyroid or even pure parathyroid feeding can control the disease in animals. According to Biedl [16] (p. 321) "the sequellæ of parathyroidectomy cannot be prevented by parathyroid feeding." MacCallum [34] reported benefit as the result of intravenous injections in parathyroidectomized dogs of very large amounts of prepared parathyroids of dogs. Administered to animals in subcutaneous injections, thyroid gland derivatives have proved inefficient, whereas parathyroid products are said to have met with some success at the hands of Beebe,[43] and others. With the nucleo-proteid Beebe claims that amelioration or disappearance of the symptoms is almost constant.

Uncertainty prevails as to the effect of transplantation. Transplanted parathyroid tissue survived in the animal experiments of Cristiana,[44] and became atrophied after a variable time in the experience of Camus,[45] whereas Lusena [46] refers to cases in which the subcutaneous transplantation of parathyroid seemed to have a decidedly favorable effect.

Of the applicability of the above methods in man little has been demonstrated. Here the effects of treatment are difficult to estimate because of the impressionable character of the patients and the frequent modification of the disease by hysterical manifestations. Some successes with thyroid feeding have been reported, as stated above, and MacCallum,[47] Marinesco,[48] Lowenthal and Wiebrecht [42] and others have reported improvement following the administration of parathyroid material by mouth. Yet the results in animals apparently have demonstrated that in the treatment of tetany by parathyroid therapy, subcutaneous administration is the means which offers the best prospect of controlling the disease. Beebe's nucleo-proteid at present appears to be the most efficient product for this purpose.

There is no record before the present of attempts to establish a permanent cure in man by parathyroid transplantation.

Transplantation.—The important part which tissue transplantation now occupies in the experimental work which is being done in tetany, and its peculiar significance as a possible therapeutic agent in this disease warrants a brief review of the main principles of the subject.

Parenchymatous organs, in part or in entirety, seem to have been successfully transplanted in a number of cases between animals of the same species, and even between human beings. But the transplantation of such tissue from an animal to man or experimentally between animals of different species, has almost * uniformly failed, presumably by reason of some cytolytic property of the fluids of an animal towards tissues of another species. The implanted tissues certainly do not abide permanently, and temporary functional effects may fairly be assumed to result from absorption of the implanted tissue and its juices.

The behavior of individual glandular organs when transplanted is extremely variable. According to Payr,[50] those organs which have an internal secretion seem to be far better adapted to transplantation than those with an external secretion.

Of parenchymatous transplantation, that of the thyroid gland is by far the most important. The original experimental transplantations of this organ in animals were done by Schiff,[51] and the first attempt in man was made by Kocher in a case of cachexia strumipriva (1883). The functional results in both instances were transient only. It was tried by Bircher[52] and others for myxedema, but with similar results.

The first attempts which seem to have been successful in respect to the life and function of the transplanted thyroid tissue were those of v. Eiselsberg[53] and Cristiani.[54] But whether this functional activity is only temporary, as urged by Ender-

* Christiani[49] reported some success in the transplantation of thyroid tissue from one animal to another of a different kind.

len,[55] is still problematic. However, Payr [50] has recently reported striking and suggestive results in animals and in the human subject. He transplanted thyroid tissue from the mother into the spleen of a six year old child who was suffering from congenital myxedema. Marked improvement is said to have resulted, and to have persisted up to the time of publication eight and a half months after the operation.

Among other tissues of which successful transplantations in animals have been reported are the ovary, mammary gland, adrenal body, and kidney; in the human subject, besides the thyroid, the ovary may be mentioned.

Among Carrell's remarkable successes in transplantations of the kidney are some in which he demonstrated that the viability of the organ was preserved during an interval of two hours between its excision and its implantation. When an interval thus elapses it has been shown by Cristiani that the viability is best retained by preserving the tissue in serum from the same species of animal or in inactivated serum of an animal of another species; the ordinary salt solution proves toxic. Flexner found that this also applies in the case of pathological tissue.

As to the most favorable site for implantation, opinions differ. The main places to be considered are the subcutaneous tissue, extraperitoneal tissue, peritoneal cavity, omentum, and spleen. In determining the situation for election in a given case attention must be given to the freedom from serious danger which it offers and to its qualifications for supporting the life of the implanted tissue.

Looking now towards the possibility of parathyroid implantations, from general experience grafting between animals of different species would not appear promising; but for obvious reasons the question should be definitely settled on account of therapeutic possibilities. Between animals of the same species, on the other hand, some prospect of success seems offered. Payr mentions several cases in his experiments in which living parathyroid as well as thyroid tissue was found embedded in the spleen at a considerable interval after the

transplantation. Moreover, since his thyroid implantations were said to be functionally successful, by analogy one might reasonably look for similar results with the parathyroid. Finally, Lusena and Cristiani seem to have obtained some functional effects in pure parathyroid transplantations.

With the view of solving the therapeutic possibilities of parathyroid transplantation in man, experiments were undertaken to establish the following essential questions:

1. Can the parathyroid live if transplanted, first, between animals of different species, second, between animals of the same species?

2. If it lives, does it functionate; and, if so, is the function permanent?

In the first series, the rabbit was adopted as the donor, because of the accessibility and definiteness of the external parathyroids which were regularly employed. The dog was adopted as the recipient in both series because it seemed likely that the subsequent removal of the normal parathyroids would be relatively simple and certain. Experience showed that this choice was a mistake and that some other animal probably would have proved better.

The spleen was taken as the site for implantation because of Payr's successes and his claims in favor of it. He suggests that the spleen offers the most suitable combination of the two main factors necessary in tissue receiving an implantation, namely, high vascularity and richness in lymphatics.

The points of interest in my experiments were as follows: In one rabbit one external parathyroid was removed; the other was exposed and its size recorded; no tetany resulted. Eighteen days later the second external parathyroid had increased considerably in size. Similar enlargement has been noticed by others, and it has been suggested that it is in the nature of a compensation for the organ lost. In seven rabbits both external parathyroids were removed; there followed no tetany except in one animal which presented twitching of the head for about two days. In three rabbits complete thyro-parathyroidectomy was performed; in two, tetany developed with death in

thirty and forty hours; the third died on the ninth day, but no positive signs of tetany were noticed. In four dogs complete thyro-parathyroidectomy was performed. In all, tetany of variable intensity developed with death in two to sixteen days. In four dogs complete parathyroidectomy was done, leaving the thyroid. In three fatal tetany developed; in one, questionable tetany without death.

These results simply bear out the experience of many others in regard to the effect of removing the parathyroids. The tetany developed in the dogs in spite of the fact that in all except three of the cases implantations had been made.

Parathyroids were implanted into the spleen of twelve dogs, that is, the eight mentioned above and four others. In eight of these, sixteen rabbit parathyroid were used; in four, ten dog parathyroids. The technique of Payr was followed with some modifications. The implantations were made from eight to twenty-eight days prior to one of the above operations for removing the normal parathyroids, except in one case where the implantation and parathyroidectomy were done simultaneously.

CONCLUSIONS.

From the preceding considerations it is evident that the removal of all and possibly even of a part of the parathyroid bodies results in tetany, that the symptoms of this disease are striking, that the diagnosis is usually simple, and, finally, that efforts directed towards its cure have not as yet been proved to be successful.

In the case reported at the beginning of this paper, the diagnosis of tetany was based, in the absence of thorough electrical tests, first, upon the fact that the patient had never presented any hysterical or other nervous manifestations previous to the onset of the typical clinical features of tetany four days after an operation for goiter which thus supplied a direct anatomical basis for the disease: second, on the analysis of the symptoms, the most suggestive features being the frequent attacks of symmetrical and bilateral tonic contractures of hands and feet, the involvement of the flexor muscles exclusively, the

presence of Chvostek's and Trousseau's signs, the latter characterized by slow contractions accompanied and preceded by cramp-like pains, the additional demonstration of the mechanical excitability of the motor nerves by the stretching of the sciatic nerve and nerves of the brachial plexus; and, finally, the fact that coincidently with the typical spasms all of the above tests disappeared.

Assuming then that this was a case of true tetany, the explanation must be that at her former operation in Bern two parathyroids were removed with the left lobe of the thyroid. Since no symptoms occurred until after my operation this was undoubtedly the cause, presumably through the sacrifice of sufficient parathyroid tissue to upset the functional equilibrium, which must have been at that time very unstable as the result of the previous operation. It is not possible that both the remaining parathyroids were sacrificed, for in that case a fatal tetany would undoubtedly have resulted. Since no parathyroid could be found in the tissue removed, it is probable either that the lower and inferior one of the right side was crushed in the clamp which was placed across tissue in which this body sometimes lies, or that the blood supply of one or both of the parathyroids on this side was interfered with by the ligation of the inferior thyroid artery. The latter explanation was suggested to me recently by Dr. W. G. MacCallum.

In this case, although improvement and apparent cure resulted during the administration of Beebe's nucleo-proteid and after the subcutaneous implantation of human parathyroids, the fact can not be lost sight of that the improvement may have been due to a compensatory hypertrophy of the upper right parathyroid body which is supposed to have been left. Although it seems probable, on the basis of this case and the investigations of others, that by appropriate organotherapy the symptoms of tetany can be controlled at least temporarily during the administration, the question has not been definitely settled. Moreover, the effect of transplantation is still problematic. From animal to man it offers no prospect of success; and we are forced to admit that it is uncertain whether para-

thyroids transplanted between animals of the same species, even under the most favorable conditions, can functionate, even if they do survive. It is consequently equally questionable whether they can grow and functionate when transplanted from man to man. Although subcutaneous implantations seem warranted on account of their freedom from danger and the possibility that they were effective in the case under discussion, the obvious technical difficulties and dangers of implantation into such a place as the spleen, are so great as to forbid the attempt until success in animals has been thoroughly demonstrated.

Considering then the uncertain status of all proposed methods of treatment, the importance of prophylaxis is self-evident. In this connection it is significant that the frequency of the disease has markedly diminished since the adoption as routine practice of leaving part of the thyroid in goiter operations.

The practical side of this subject has been furthered by recent researches only in so far as it has been demonstrated that not merely sufficient thyroid must be left in order to prevent the occurrence of myxedema, but also that a definite part of the thyroid must be retained in order to ensure sufficient parathyroid tissue and thus guard against tetany. The truth of this statement is demonstrated by the case presented in this paper and by the cases of tetany following partial parathyroidectomy collected by Pineles and quoted above with later additions.

The operator must attempt to leave at least two of these bodies in situ, with blood supply unimpaired. When we consider how difficult it is to locate the parathyroids at autopsy on account of their small size and variable situation, it is evident that under the conditions which prevail in an operation, their recognition could not be depended upon and would prove a matter of chance. Therefore, in order to preserve the parathyroids, it is necessary to leave the posterior part of at least one lobe of the thyroid, in connection with which two of these bodies usually lie. Whether this is done by leaving one lobe

completely or in part, is a matter for individual choice in a given case; but in pursuing either course the thyroid vessels, especially the inferior, on this side should not be ligated. The practice of leaving the isthmus only is obviously a very dangerous procedure. In addition, to ensure still further immunity from tetany, even when one entire lobe or the posterior part of a lobe is left, certain precautions should be taken if the whole of the other lobe is removed. In the removal of this lobe the dissection of the thyroid gland should be carried as close as possible to the true capsule of the organ, and independent, small bits of tissue should be sought for in this situation, stripped from the thyroid, and left uninjured. Moreover, in ligating the inferior thyroid artery on this side care should be taken to avoid including in a ligature or clamp the inferior parathyroid which frequently lies in close relation to this vessel.

From the preceding review and discussion it is evident that numerous questions relating to the parathyroid bodies and tetany are still unsolved. Two important points, however, may be accepted as proved by the overwhelming evidence of experimental and clinical observations: first, that tetany following goiter operations is due to operative interference with the parathyroid bodies; and, second, the corollary of this, that in operative procedures parathyroids and their blood supply must be maintained inviolate.

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OBSERVATIONS UPON A FORM OF EXOPHTHALMIC GOITRE OCCURRING IN A DOG.

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AND

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OF NEW YORK.

THE history of this case was briefly as follows:

The mother was an imported Irish terrier brought over on a cattle ship. She was badly treated during the trip and also for some time after her arrival in this country. At length she was picked up by a stable hand, who kept her in a rather cold, dark and damp stable. Her neck had always been noticeably full, but not remarkably so. Under the stableman's care, she revived and became bright and active. About eight months later, she gave birth to a litter of pups. These were sired by a thoroughbred Irish terrier. He also had been kept under poor hygienic conditions in the cellar of a saloon.

There were five pups. One, a female, was drowned at birth. Another died early from some unknown cause. About three weeks later, the remaining pups were all observed to have a swelling in the neck and they seemed to be weak in their hind quarters. Unfortunately no particular attention was paid to them until one died with symptoms that were noticeably like those of exophthalmic goitre. The two remaining pups were then seen by a member of the Surgical Research Laboratory staff. He noted that the thyroid gland was markedly enlarged; that the hind quarters of the dog were very weak; that the pulse was exceedingly rapid and that there was a very marked movement of the thoracic wall and indeed of the whole body due to the violent heart action. A very fine muscular tremor was quite marked.

One of the two remaining pups died before operation was decided upon, and the body unfortunately was destroyed before an autopsy could be performed. The last pup was then taken to the Laboratory and there presented the following symptoms:

A very marked swelling of the thyroid gland which was more prominent on the left side. It was elastic and throbbed synchronously with the pulse. The pup was extremely weak in the back and hind legs. When the photograph in the accompanying cut was taken, the animal was unable to stand and had to be supported as shown. There was very marked tremor. Little or no exophthalmos was present. The pulse had exaggerated force. It ran between 160 and 170 and was of high tension.

Upon the history, the presence of the tumor, the tremor, and the

tachycardia, a tentative diagnosis of exophthalmic goitre was made and operation decided upon.

The dog was given a dose of morphine hypodermically and when under its influence was anæsthetized with ether. The thyroid gland was exposed through a median incision. It was found to be enormously enlarged and to have an abnormally large vascular supply. The left lobe was larger than the right. The isthmus was ligated in two places and was carefully divided between ligatures. The gland was found to be well encapsulated and it shelled out easily. The parathyroids were not seen. The wound was washed out and closed with a continuous silk suture and dressed with a formalin pad. The pup re-acted well after the operation.

The next day an immediate improvement was noticeable in the animal's condition. The pulse rate had fallen to 120 and the impulse of the heart-beat against the chest wall had diminished very appreciably. Prior to operation it had been possible to count the heart beats by simply looking at the animal's body. After operation, this could no longer be done.

Four days after operation, the pulse had reached 90. There was no longer any impulse transmitted to the hand. The animal's general condition improved rapidly. He gained weight and all tremor disappeared. Weakness, however, persisted for some time, but at the end of two weeks, he was in a reasonably normal condition. The animal lived for six weeks after operation and died without giving any manifestation of a recurrence of the symptoms described.

Dr. MacCallum, of Baltimore, in speaking of this case, said:

"I should think it difficult to make a definite diagnosis of exophthalmic goitre in a dog, but I think the histological character of the goitre would furnish the best evidence of the nature of the condition. The literature is very meagre and I think any such case ought to be reported." Dr. F. C. Wood, of the Path. Dept., stated that this gland, a section of which is here shown, presented the usual morphology of exophthalmic goitre. His language is as follows:

"The microscopical examination of the thyroid tumor which you sent me some time ago, shows a growth of the type which we are accustomed to see in exophthalmic goitre in man."

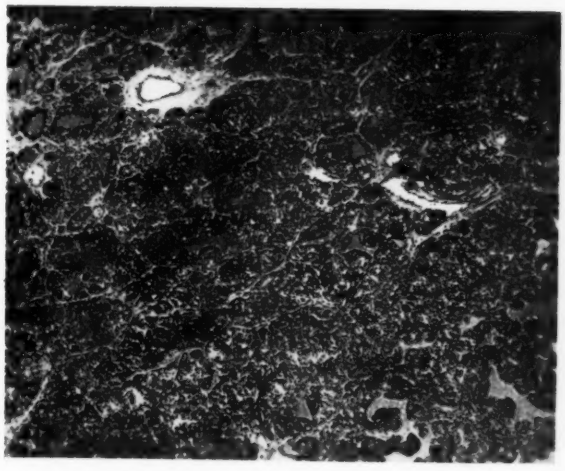
Woods Hutchinson says: "I can quite readily imagine such a condition of affairs developing in the dog, as ordinary cystic and fibrous goitres are quite common in the species and generally give rise to few or no symptoms except those connected with their size. Similar conditions are also fairly common in horses and sometimes give rise to some difficulty, through pressure upon the trachea, and pneumogastric. I have also reported briefly a number of cases of cretinism occurring in puppies in goitrous regions, particularly in the Yakima and Puyalap valleys in Washington."

Wesley Mills, the well-known authority on dogs, writes from McGill University in reference to this case: "I have worked upon the effects of removal of the thyroids and parathyroids in dogs and I have seen a good many cases of ordinary chronic enlargement of the thyroid, but such an

FIG. 1.

Goitre in the neck of a dog.

FIG. 2.



Exophthalmic goitre in dog.

acute case as you have had the opportunity to study has not come to my notice. In all my study of the dog, I have been impressed by his resemblance to man, both physically and psychologically. The chronic enlargement of the thyroid always gave way in my experience to the treatment usually employed for human beings. I see no reason to doubt that your case was one of exophthalmic goitre."

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EXPERIMENTAL STUDIES UPON THE THORACIC ŒSOPHAGUS—A PRELIMINARY REPORT.

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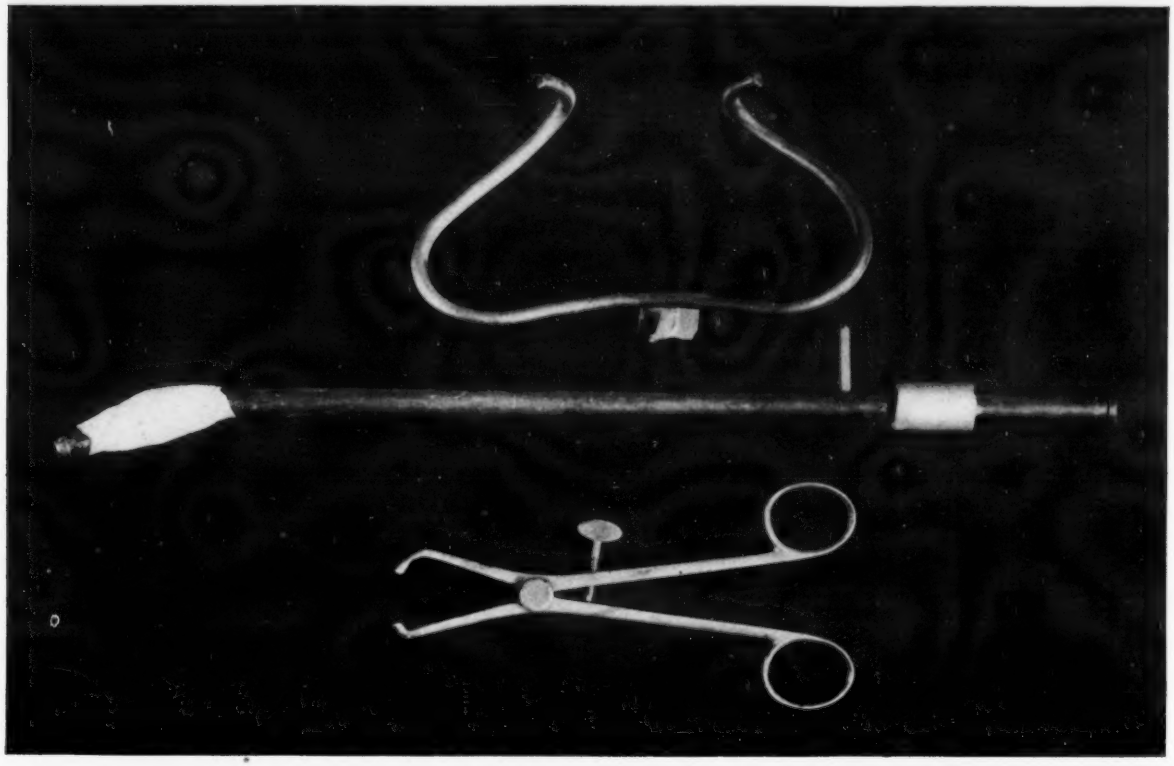
THE purpose of the experiments outlined in this report is to determine what can be done transpleurally in the treatment of œsophageal stenosis while using the more simple positive pressure method of overcoming the embarrassment necessarily due to collapse of the lung during open chest work.

A few words may first be said concerning the apparatus used, the construction and the method of introduction of the intra-laryngeal tube. The air pump and valve is that designed by Mr. J. T. Hoyt of the physiological department and is of the type mentioned in a former paper.[1] The means of conveying the ether vapor is also the same as used in the experiments detailed in that paper. The canula, however, is much simpler and consists of a plain 8 mm. brass tube 12 in. long slightly curved and rounded at the laryngeal end and supplied with an obturator which tightly fits the rima glottidis. This consists merely of a few turns of surgeons' plaster so wound around the tube as to make a fusiform enlargement of about 12 mm. at its maximum diameter (see photo., Fig. 1). In the side of the tube near the aboral end is bored a small hole of about 2 mm. diameter. This serves as vent for the expired air. Around the tube is a small collar, a piece of tubing, which may be slipped over this aperture when it is necessary to inflate the lungs thoroughly before closing the chest wound. The aperture is sufficient for all expiratory purposes. No partial

[1] The Positive Pressure Method of Artificial Respiration with a Practical Device for its Application in Thoracic Surgery.—Surgery, Gynecology and Obstetrics, May, '06.

FIG. I.



Instruments to facilitate intra-thoracic work. A match has been inserted in the vent hole referred to in text.

vacuum is used as it was demonstrated to be unnecessary. The intubation tube is held firmly in place by a light clamp made by incurving the blades of an Otis meatal dilator. This clamp is applied oral to the hyoid bone and is so adjusted as not even to bruise the skin under the floor of the mouth. Yet this simple appliance serves to hold the intubation tube firmly in place, and it was noticed repeatedly that neither the pressure from this clamp nor that exerted by the tube itself upon the vocal cords was sufficient to cause the least sign of paralysis. This was shown by the ability of the animal to bark immediately after recovery from anæsthesia.

The introduction of the tube is a very simple matter if attention be given to the following details. In the first place, the primary anæsthetization must be profound. The dog should then be placed squarely on its back with head extended. An attendant slips a towel over the canines of the upper and another over those of the lower jaw holding the mouth very widely open. The operator then holds the tongue in a third towel and draws it forward until the epiglottis is seen. If strong sunlight be thrown from above on the exterior of the neck, the proceeding is much facilitated, for it gives a very striking illumination through the tissues and enables the operator to place the tip of the intubation canula directly in the open rima.

Having completed the intubation and having secured the tube with the clamp, the dog is placed on its right side, a small cushion being tucked underneath the body opposite the site of the operation.

The 6th intercostal space is then located by counting from below up. The skin and superficial muscular incision is made over this space. The tissues are then drawn downward and the pleural cavity opened by sectioning the intercostal muscle midway between the ribs in the 7th space. This gives on closure of the wound an air tight flap—a condition very necessary in the dog, as leakage of air into one pleural space causes collapse of the opposite lung owing to the mobility of the soft parts forming the mediastinum.

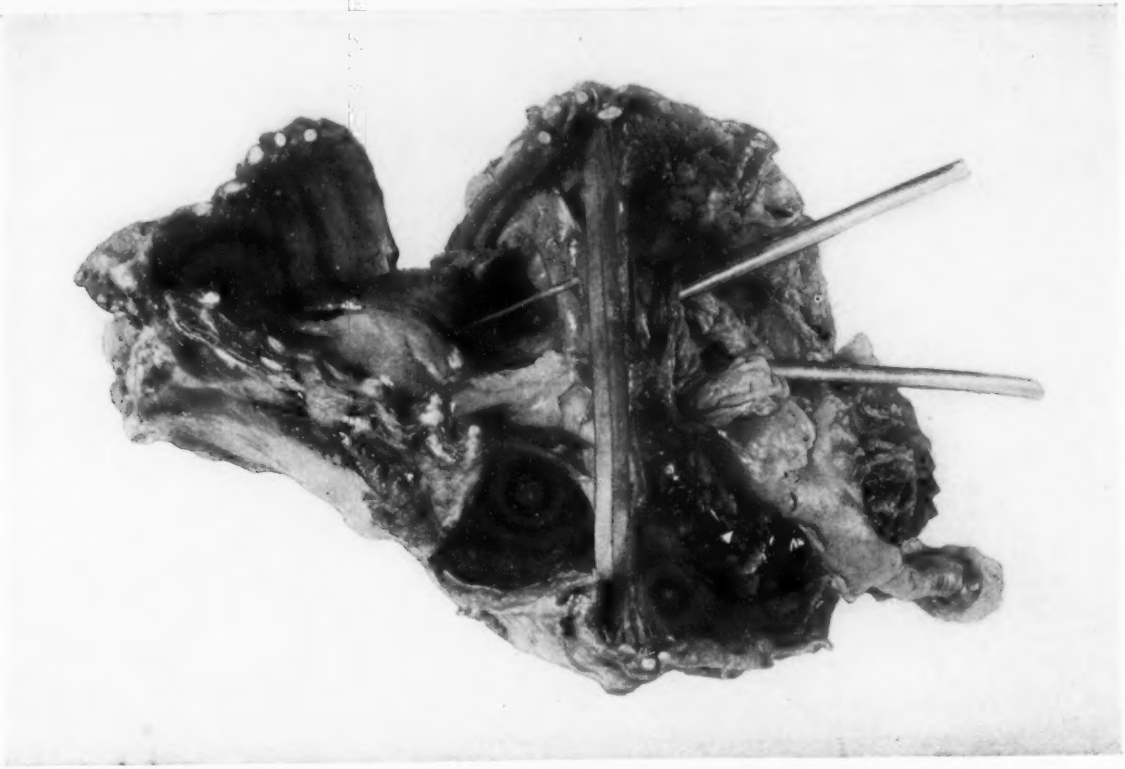
Before the pleuritic layer is opened the condition of the lung should be studied by direct inspection and the amount of expansion regulated. This can easily be done as the pleura is quite transparent. Regulation of the expansion may be effected by gauging the volume of air delivered and by changing the size of the expiratory vent by the rubber collar already referred to.

Having opened the pleura, the ribs are then drawn apart and a self-retaining retractor inserted. This retractor, as shown in the photograph (Fig II), consists of a bent brass rod, it having been found more serviceable than the larger instrument designed for human use. The lung is then held out of the way by delicate retraction. This allows an immediate and unobstructed view of the œsophagus, for the ribs at the point of entry separate quite freely.[2] The vagi are usually found as two large trunks with a diagonally communicating branch. From this point on the manipulations must be of the most delicate nature possible. The vagi are carefully separated from the œsophagus by sharp dissection for a distance of 5 cm. Unavoidably much of the serous covering of the œsophagus is removed at this time, but it should be preserved so far as possible. At a point about 1 cm. oral to the point of investiture of the œsophagus by the diaphragm, a cuff of serosa is separated by circular incision around the œsophagus and this cuff is stripped down until the stomach appears in the wound.

The beginning decussation of the vagi on the stomach and the vessels, with the frequent exception of one branch which must be tied—are pushed back on the stomach. At this point the peritoneum appears on the left side and must be opened about half way around the œsophageal end of the stomach. After carefully protecting the cavities by pads a portion of the gastro-œsophageal juncture 2 cm. or more in length is removed. Clamps should not be employed as their use may be followed by a late perforation at the point maximum of pressure. Two retraction Lembert sutures are placed

[2] See abstract Sauerbruch's recent technic Kocher: Chirurg. Op. V aufl. p. 737 *et sec.*

FIG. II.



Photograph of entire chest. Ribs spread apart by piece of wood. Stomach split near greater curvature and sounds introduced through the separate openings into œsophagus. A sequestration operation.

FIG. III.

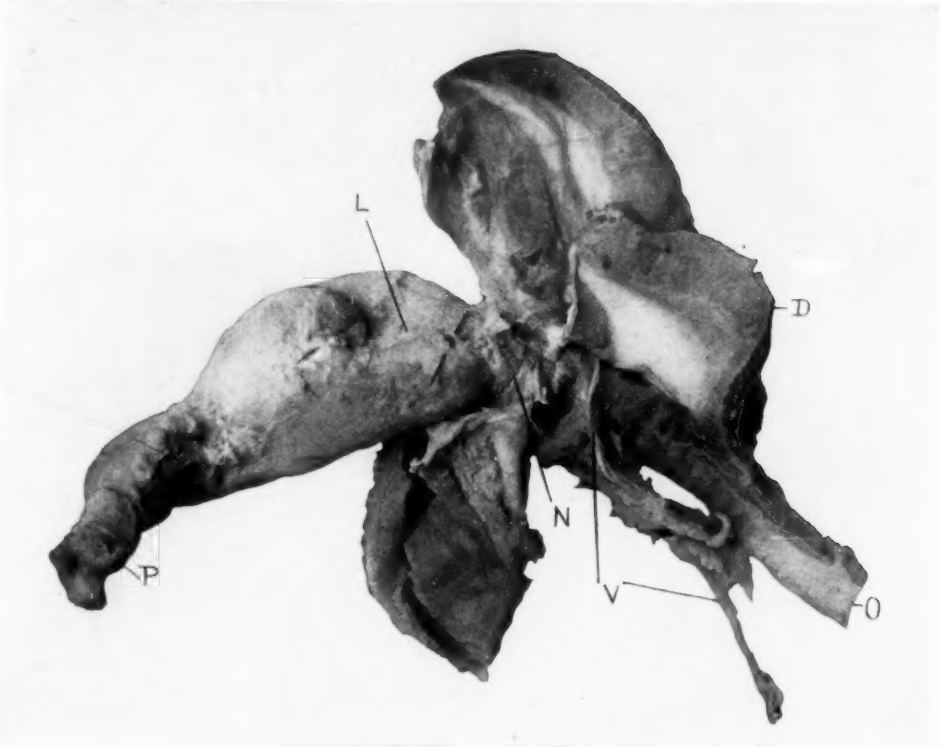


Figure showing appearance of tissues and relations of parts after intra abdominal sequestration of gastro œsophageal union. P, pylorus; L, line of union (between pins) where normal opening of œsophagus was closed; N, new line of union of œsophagus to stomach; D, diaphragm which is seen to be oral to N; O, œsophagus; P, Pylorus, V, vagi.

in the oral part of the œsophagus which is then drawn up into the thoracic wound; the opening plugged with gauze and the stump covered with a pad. The wound caused by the resection of the gastric wall is then closed by a three-layer suture and the stomach is dropped back into the abdominal cavity. An adjacent portion of the cardiac end of the stomach is then grasped in the fingers and drawn up into the chest. Two retraction Lembert sutures are placed in the stomach and this organ incised between them. An end-to-side implantation of the œsophagus into the stomach is then made according to the usual method, three layers of silk sutures being used. The stomach is then dropped back into place again and the diaphragm sutured to the œsophagus oral to the point of union with the stomach, so making the gastro-œsophageal suture line intraperitoneal and within reach of the omentum (Fig. III). The chest cavity is then freed from any blood clots remaining, the positive pressure is slightly increased and the chest wound sutured in layers, leaving a small opening for the escape of air while the lungs are fully distended. This is finally closed and the operation is completed.

The conclusions from these incomplete studies are as follows:

Intubation practised with the simple instruments described is thoroughly practical and for all surgical research work should supersede tracheotomy.

Positive pressure if supplied with a proper cut-off valve is a simple and efficient means for producing artificial respiration in surgical work. We have had no death directly attributable to it.

The flap formation in the chest wound is an important point in the technic.

The protection of the pleural cavity from infection must be rigidly enforced and when the point of resection is near the cardia this may be conveniently accomplished by the sequestration of the gastro-œsophogeal wound into the abdominal cavity. The omentum will then apply itself to the wound area as in any intestinal operation.

Efforts to carry a portion of the omentum into the chest in order to profit by its protecting influence in case the wound area was too oral to allow of intra-peritoneal sequestration were sometimes successful, but it is difficult to maintain the omental blood supply by the method we employed.

In connection with these experiments we wish to report that we have tried gastro-œsophagostomy by means of the Murphy button—by means of end-to-end suture bringing the stomach up through a new opening in the diaphragm—by a lateral anastomosis, by one and also by two stages—and by the twine triangular stitch.[3] This last method we found very satisfactory in side-tracking the natural cardiac orifice. The photograph (Fig. IV) shows a view of a specimen so obtained. Our experience to date leads us to the belief that this or a two stage operation will prove to be the one of election, for the simple one stage intra-thoracic œsophageal section has a very high per cent. of septic mortality (in dogs).

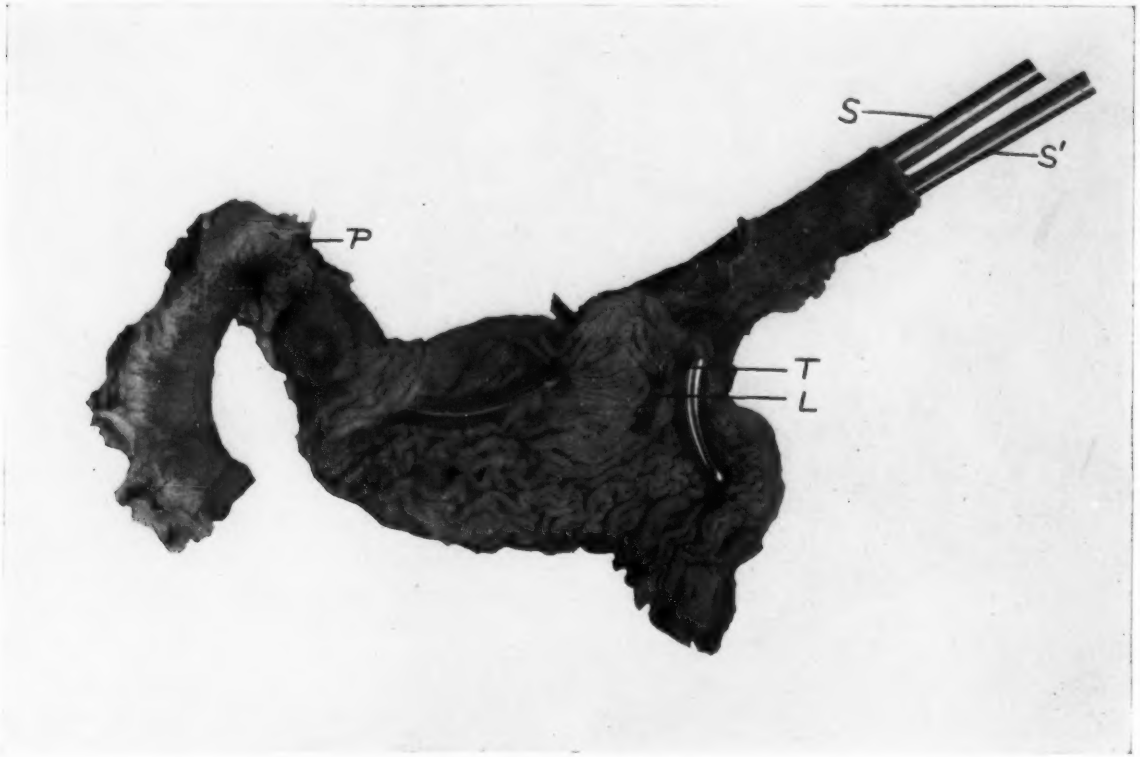
We have also attempted Roux's method[4] of œsophago-jejunostomy. His technic was followed in all respects save that the gut segment was carried up through the chest instead of subcutaneously. Kocher,[5] after describing the method outlined by Roux, states that he essayed it on a man but was obliged to proceed to simple jejunostomy because of the failure of circulation in the isolated jejunal segment. Our results appear to justify the conclusion that in dogs at least the isolation of a portion of the jejunum by Roux's method is impracticable because of circulatory failure.

[3] Twine in lieu of the elastic ligature for performing gastroenterostomy, Jour. A. M. A., Sept. 17, '04.

[4] Semaine Médicale, Jan., '07.

[5] Chirurgische Operations lehre, p. 907.

FIG. IV.



Photograph of specimen obtained by using the twine triangular stitch for gastro-esophagostomy, S S' are sounds which enter œsophagus orally; S' passes through the triangular stitch opening; S, through natural opening and on into pylorus P; L is a finger of lead pointing to T, the triangular stitch which is just hanging to the margin of the stoma.

STUDIES UPON THE FUNCTION OF THE PYLORUS AND STOMA AFTER GASTROENTEROSTOMY HAS BEEN PERFORMED.

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AND

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A GREAT deal of speculation has been indulged in as to the physiological conditions which exist after the operation of gastroenterostomy. Undoubtedly the most important and thoroughly scientific and accurate observations were made by Cannon in his recent studies at the Harvard Medical School. Together with Murphy, he performed the operation of gastroenterostomy on a large number of cats, and after full post operative recovery, studied the animals' intestinal mechanism through the agency of the fluoroscope. He found according to these observations that all food was driven by the muscular contractions of the stomach through the pylorus, the stoma playing no practical part in alimentation. This was a profoundly important contribution.

About a year ago, the class in operative surgery at the Surgical Research Laboratory at Columbia University performed the operation of gastroenterostomy. We were making some observations upon the efficacy of various forms of superficial dressings, and in this particular case, a certain dressing was applied upon a small piece of gauze. While not under observation, the animal picked out the smaller dressing from under the external bandage and swallowed it. Some time after this, he was chloroformed for the purposes of study, and upon opening his stomach, the gauze was found trailing through the stoma. We were immediately interested in this, because Cannon's observations had just been published. Unfortunately no record was made as to the direction taken by the tip of the gauze which had passed through the stoma. This is unfor-

tunate, because later observations suggest that solid bodies, which pass through the stoma, may all travel toward the pylorus.

During the past winter we determined to study this interesting problem of pyloric and stoma function and decided to investigate it from three standpoints, viz. (1) By studying the course taken by solid particles which were tied to a string. (2) By feeding fat and studying the condition of the lacteals an hour later. (3) By performing gastro-colostomy or gastro-ileostomy near to the valve and making observations upon the weight of the animal. For the feeding of string, no originality can be claimed, it having been used for many purposes notably by Abbe and Dunham. The particular purpose to which we have put it, however, we believe to be original. We conceived the idea that if gastroenterostomy were done and time allowed to elapse for the perfection of healing and for the establishment of any new physiological functions to which origin might be given by the operation, it would be fair to assume that solid food particles ordinarily passed on and digested, would take the same course as indigestible solid particles tied to string. The dogs accordingly underwent gastro-duodenostomy or gastro-jejunostomy, as the case might be, the technic being that of open incision and suture. Not less than two weeks later, they were permitted to swallow a piece of meat in which a small bullet, tied securely to the end of a piece of string, was embedded. A dog lends himself favorably to this manœuvre, because of his natural voracity. In an instant the meat, bullet and one end of the string are in his stomach. The next part of the procedure consists in anæsthetizing the animal to very profound narcosis. On separating the jaw very widely the pterygomaxillary ligament is brought clearly into view. The string being threaded on a short curved round needle is quickly passed through the ligament and tied. This should be done loosely so as not to cut through. Another point in the technic is that the string should not be tied to the meat: it being preferable probably to wrap it once or twice tightly around it.

The pterygo-maxillary ligament is situated so far aboral to the teeth that the animal does not bite the string off, and it remains hanging down the œsophagus. Its situation is so far

FIG. I.

LINE DRAWING OF A SPECIMEN OBTAINED BY PERMITTING A DOG TO SWALLOW A PIECE OF STRING. BAG OF SHOT TIED TO END PASSED THROUGH THE STOMA, DUODENUM AND PYLORUS TWICE THE SAME FORCES MAY CARRY MURPHY BUTTONS FROM THE GUT INTO THE STOMACH.

STRING TIED IN PHARYNX TO PTERYGO-MAXILLARY LIGAMENT.

back in the pharynx that the string will remain for days in this position without creating any choking or discomfort of any kind whatsoever.

It is difficult to get the string to pass out of the stomach. If it is too long, it simply rolls up and lies in the stomach

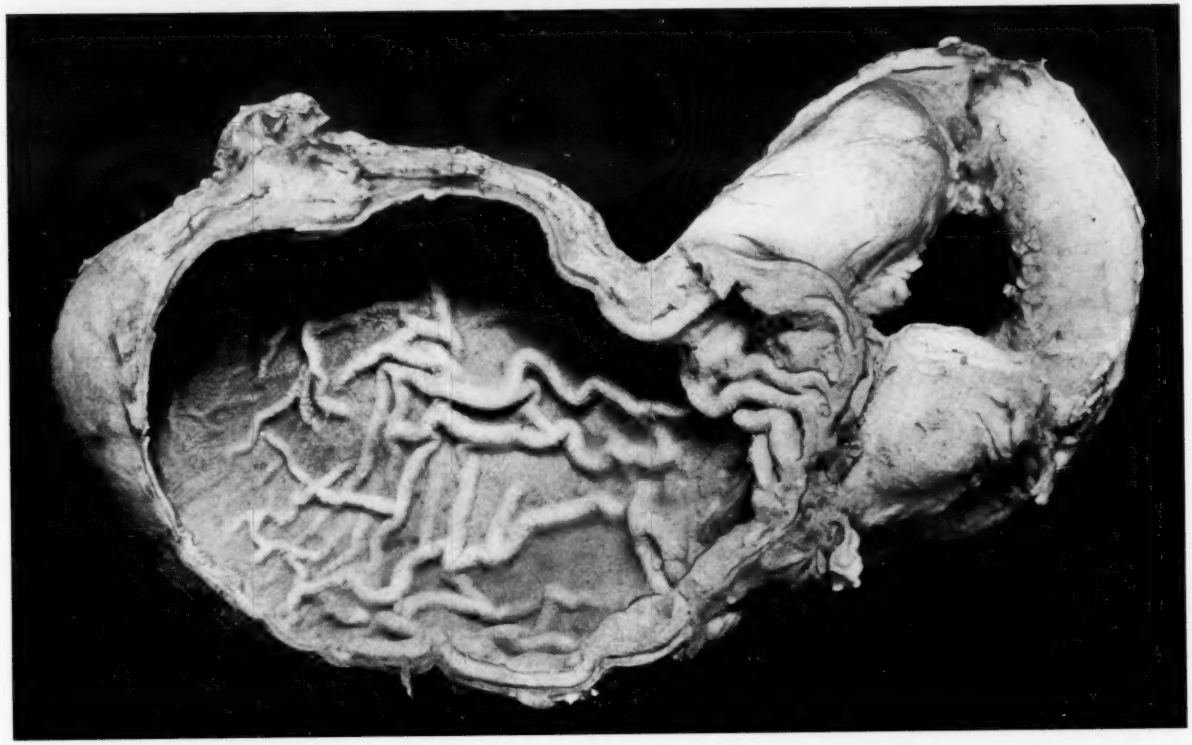
imbedded in a mass of mucus and food. If too short, it will obviously not have the requisite length to give a demonstration of the facts under investigation. We are fortunate in having secured a specimen which Dr. Brown has mounted very beautifully, and of which both a photograph and a line drawing are shown in the illustrations Figs. I and II; it will be seen that the bag of shot passed directly into the stoma and instead of travelling aboral, it proceeded oral, Fig. II, toward the pylorus through it and into the stomach. Following the trail of string which it left behind, it can again be traced over exactly the same ground. This study appears to prove that at least under certain conditions and at certain times solid materials do pass through the stoma even when the pylorus is left untouched and it is in normal condition. This is further suggested by Fig. III, which shows a piece of *bone* lodged in the stoma. The results of further string feeding are shown in Fig. IV. This string passed direct through the pylorus. Thus some strings pass one way and some the other way. Figs. V and VI illustrate the same point.

Pyloro Stoma Function as Demonstrated by the Lymphatics.—We are fortunate in being able to report one case which lent itself very favorably to this demonstration. We had fed the dog string, and it had worn the string for the usual period of about 24 to 48 hours, when we determined to feed it fat prior to chloroforming it. About one hour after the fat meal, the animal was opened under profound anæsthesia. The gastro-ileostomy had been situated near to the ilio cecal valve, as shown in Fig. VII. By good fortune the mass of meat in which the string with its shot had been imbedded proved to be of a very indigestible type, and it was discovered considerably macerated but still in statu-quo lodged in the ileum about 20 centimeters oral to the stoma. The lymphatics of the duodenum from the very beginning of the mid gut, viz., some four to five centimeters aboral to the pylorus, were loaded and distended with emulsion. This, parenthetically, affords a convenient means of observing the similarity in function of the stomach and first portion of the duodenum from which no

FIG. II.

Photograph of specimen from which Fig. 1 was made.

FIG. III.

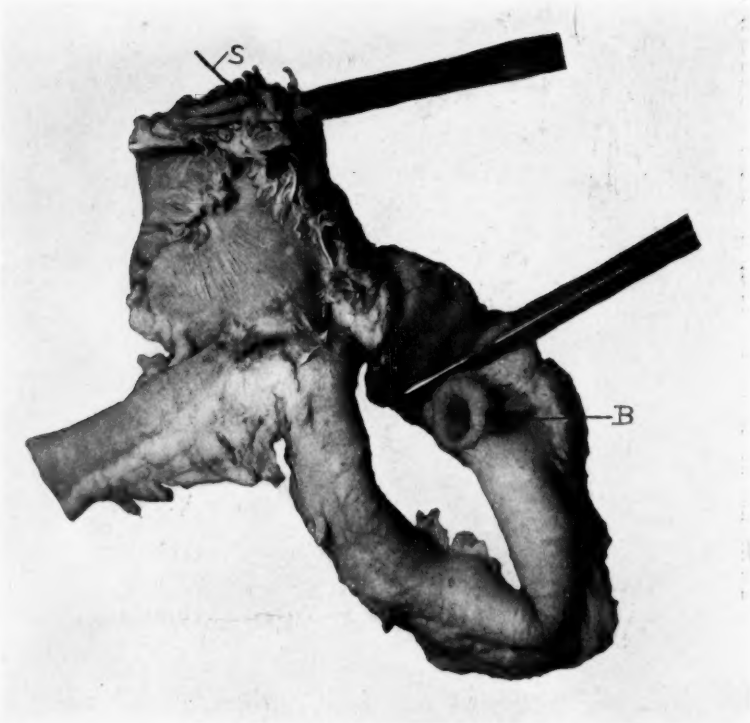


Studies in the Functions of the Pylorus.

FIG. IV.

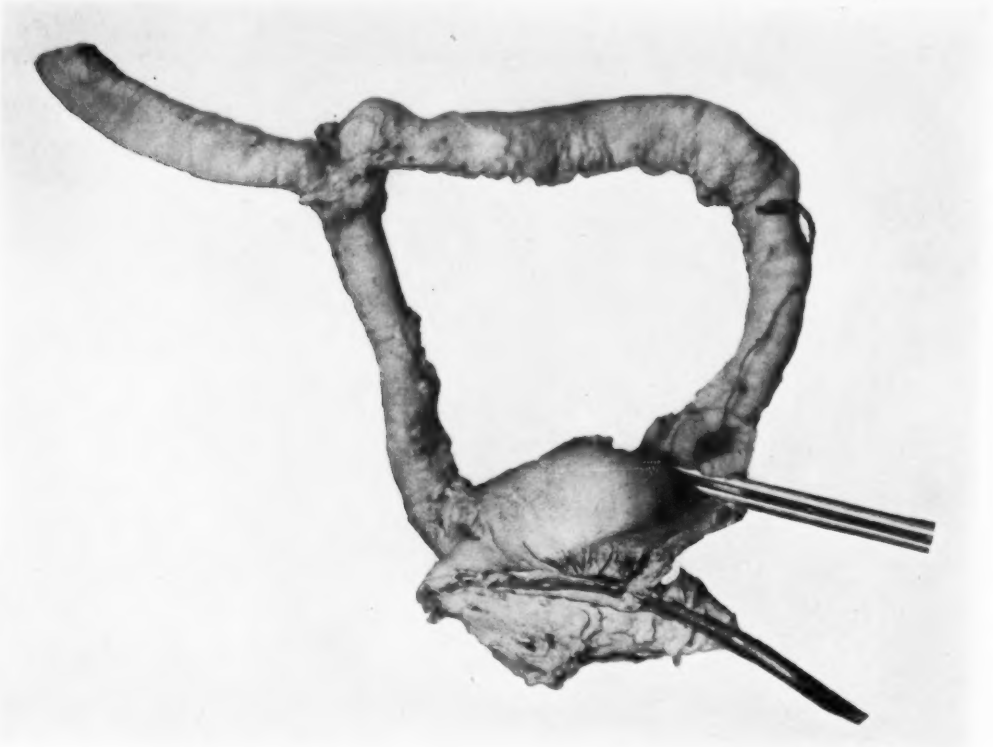
Studies on Functions of Pylorus, etc.

FIG. V.



Photograph of specimen of gastro jejunostomy after string had been fed. The clamps were applied before specimen was removed so as to be certain that string was held in primary position. Note string at S; œsophagus and bullet on aboral end at B, where duodenum was cut.

FIG. VI.



V gastro-enterostomy. Clamps applied as in Fig. V. Opening shows string which, with bullet, had passed through pylorus. This is suggestive for stoma drainage and was very perfect owing to end to side implantation of gut at stoma.

absorption whatsoever seemed to be taking place, two structures morphologically very dissimilar, but shown functionally to have a common origin in the primitive foregut.

FIG. VII.

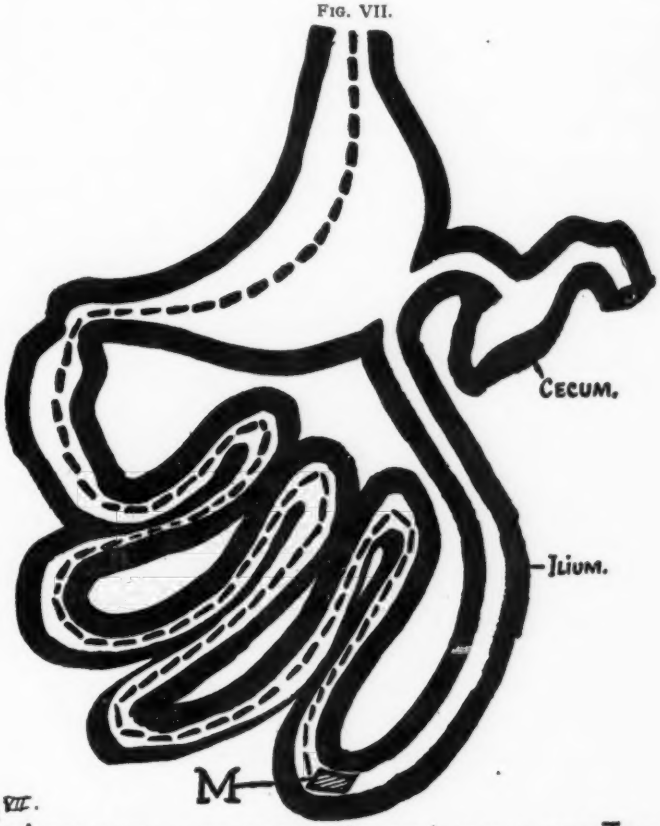


Fig. VII.

THIS DOG SWALLOWED MEAT WITH STRING ATTACHED. TWO DAYS LATER WAS FED FAT. KILLED ONE HOUR LATER. LYMPHATICS ORAL TO POINT M, WHERE MEAT LODGED IN GUT, WERE GORGED. THOSE ABORAL TO M WERE EMPTY. PROVES THAT FATS DO NOT PASS THROUGH STOMA.

The lymphatics of the entire intestine from the second portion of the duodenum down were well filled. This lymphatic congestion terminated abruptly opposite the piece of meat which was lodged in the ileum and held there in place by

the string. On the aboral side, viz., for a distance of about 20 centimeters between the lodged meat and the stoma, it was positively demonstrated that no absorption whatsoever was taking place. Aboral to the stoma there was also no lymphatic engorgement. In this particular case, it therefore seemed that probably no fat had passed through the stoma; that all had gone through the pylorus. This, of course, presupposed that pancreatic secretion had passed beyond the meat.

These two studies are suggestive and are to be followed by more of a similar nature which are in course of preparation at the laboratory. It may well be that some slight variation in the technic as to length of loop, direction of incision in the stomach wall, position on anterior or posterior wall, mode of attachment of intestine to stomach and other even less significant factors may play parts at present entirely unknown in determining the function of the stoma in the presence of an unobstructed and natural pylorus. It has been thought (Mayo and others) that the stoma should be made at the most dependent portion of the stomach in order to functionate. This can be readily understood to be of great importance in the presence of atonic dilatation and pyloric obstruction. Our experiments, as yet incomplete, seem so far to show that the position of the stoma makes no difference in its function, at least we have not as yet been able to determine that it does.

Observations on Stoma Function by Recording the Weight of the Animal.—If a gastro-ileostomy be done very near the valve or if one goes so far as to perform gastro-colestomy, a study of the weight of the animal after this operation cannot fail to throw some interesting light upon the function of the stoma. Moreover observations on the feces are also not without importance, because if passed directly through the stoma, they would not have undergone digestive processes. Graphic charts of the weights of our animals have not yet been made, neither have the feces been examined microscopically or chemically. Gross examination however has as yet failed to show any difference in the feces of dogs operated on in this manner from those of unoperated dogs, and our observations

on weight appear to show that for a time after operation the dogs, usually thin and in rather poor condition, having been half starved on the streets, frequently gain in weight for about a week. They are then apt to lose weight rapidly for a week, and even though fed carefully with milk and dog biscuits, are prone to die at the end of the second or third week from inanition. Autopsy findings rather constantly show the long loop to be somewhat dilated and filled with soft grumous material. Pretty well marked spur formation at the side of the stoma has been a constant feature in these cases. Further study alone by means of feeding string and fat by the technic and at the times herebefore described will alone answer the question why these dogs should at first gain, then lose weight and why inanition and exitus should subvene so rapidly. It is not improbable that the profound nutritional changes that certainly do accompany many of these stoma experiments are due (Turck) to interference with normal colon bacillus action or to the establishment of chemical reaction unfavorable to digestion. In any event the experiments support Blake's contention that gastroenterostomy should not be done except in the presence of pyloric stenosis.

IS DEATH IN HIGH INTESTINAL OBSTRUCTION DUE TO THE ABSORPTION OF BILE?*

BY J. W. DRAPER MAURY, M.D.,

OF NEW YORK,

Fellow of the Rockefeller Institute.

It is well known that acute intestinal obstruction occurring in the duodenum or oral portion of the jejunum is much more rapidly fatal than a similar obstruction occurring aboral to this portion of the intestine.

A rather careful study of the literature of the subject has failed to show that any definite cause has been discovered for this well known fact, everything to date being suppositional in character. So recent and so high an authority as M. Wilms, whose extensive monogram on ileus has just appeared, in discussing high intestinal obstruction says: "The time in which duodeno jejunal obstruction causes death has only in the rarest instances been prolonged. Death usually subvenes with extreme rapidity. All patients probably succumb to toxic absorption resulting from the decomposition of intestinal and stomach contents."

Starvation and lack of absorption of water, which has been thought by some to be a factor in producing the syndrome of duodeno jejunal obstruction, are hardly to be considered, particularly when one reflects that absorption of water takes place almost entirely from the colon and can therefore not be materially influenced by the position of the obstruction in the small gut. For, as Mayo says, we drink with our great gut and eat with our small. Wilms makes no mention of the possible relationship of the biliary and pancreatic fluids as a cause of death in duodeno jejunal obstruction.

Neither are these the only suggestions which have been offered as an explanation of the phenomena under discussion.

* A Research conducted under a Fellowship granted by the Rockefeller Institute.

Boszeky and Genersich offer two theories to explain the symptoms in intestinal obstruction, viz., reflex and auto intoxicational. They believe that bacteria and their toxines pass through the intestinal wall; that the slow pulse and other phenomena are caused by the interference with the vagi and splanchnics, which causes congestion of the abdominal organs, thus giving rise to anemia elsewhere, noticeably in the brain. The anuria which is characteristic of this condition is due in the opinion of these two authors to exhaustion of vaso dilators of kidneys and the drop in temperature to exhaustion of the heat centre, all due to cerebral anemia. "But," they continue, "in cases of obstruction by enteroliths, these symptoms cannot be explained on the ground of nervous phenomena. Here it must be chiefly an accumulation of feces and ptomaines and toxines due to *putrefaction of intestinal contents.*"

Here again in an exhaustive German monograph attention is called to the importance of putrefaction of the intestinal contents. Observations which we have made in the Laboratory show conclusively that putrefaction has nothing whatsoever to do with the cause of death in intestinal obstruction, at least when the seat of obstruction is within 35 centimeters of the pylorus.

Accidentally in the beginning, and, more recently, volitionally, we have studied this obscure but exceedingly important problem. It will be necessary in order to make our results clear, to give a short history of the manner in which the subject has been approached.

In a series of experiments conducted in the Surgical Research Laboratory of Columbia University and which were carried on to find some practical method of performing a gastroenterostomy by the so-called closed method, it was noticed that under certain constant conditions the animals operated on invariably suffered a similar train of symptoms which were always followed by a pseudo tetanic form of death. The pathological picture marked by fibrillary muscular twitchings, weakness and later rigidity is not unlike that presented after a parathyroidectomy. The conditions which

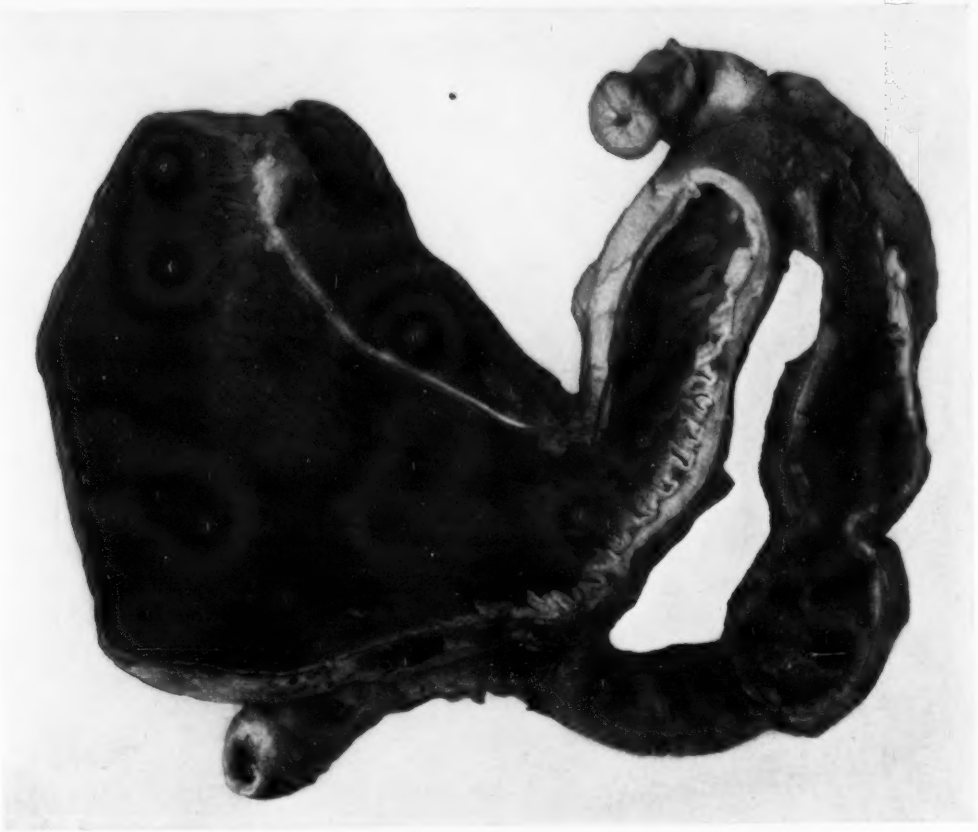
united to cause this precise form of death are shown in the accompanying outline (Fig. 1). They consisted in the performance of a gastroenterostomy by a closed method and the severance and closure of the short duodenal loop. The actual technic of effecting the establishment of the stoma is not of immediate concern here. It was made by what has been called

FIG. 1.

INTESTINAL OBSTRUCTION AT A POINT JUST ABORAL TO DUCT OF SANTORINI.
STOMACH AND DUODENAL POUCH CLOSED.
THE TWINE-TRIANGULAR STITCH WILL DRAIN IN 72 HOURS.
C.B.D.
D.W.
D.S.

in previous communications the *twine triangular stitch*. It is necessary, however, to emphasize the fact that this triangular stitch, which is a simple substitute for the McGraw elastic ligature, has been introduced in all the series as a control. It is of great use for experimental purposes when it is desired to close the stomach for a constant number of hours and subse-

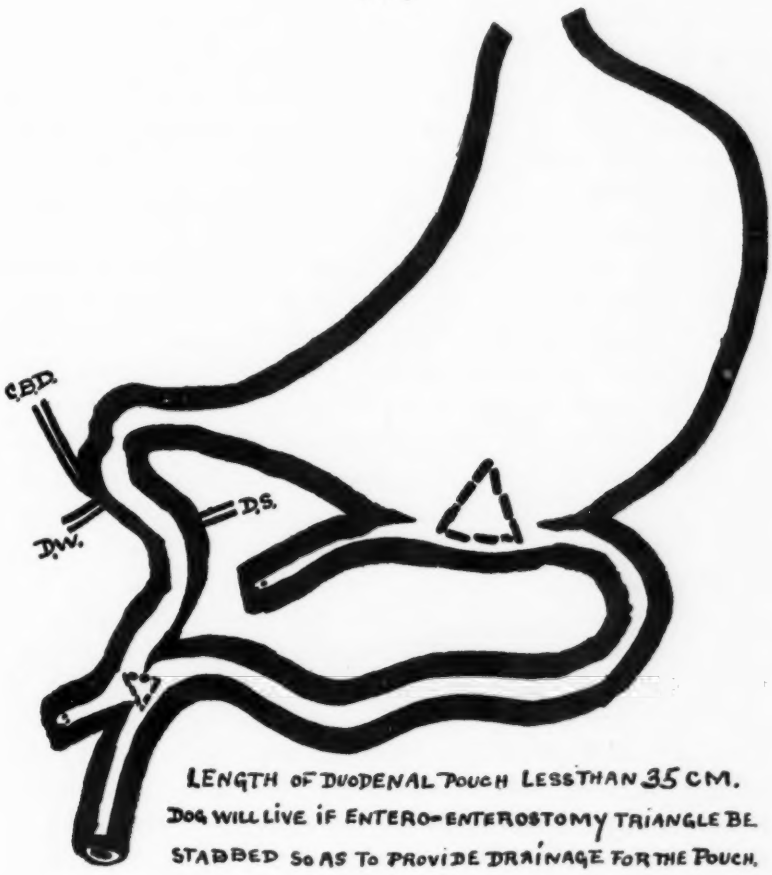
FIG. 2.



Intestinal obstruction. Photograph showing entro-anastomosis (open). Gastro-enterostomy triangular stitch (closed). Animals live if loop be drained. Note the enteroliths which formed in end of intestinal pouch.

quently to have drainage re-established. The twine cuts a punched out opening at a period of from 70 to 100 hours. This varies in different subjects, but in long series a general average will be maintained. This is the first point to make clear.

FIG. 3.


C.B.D.
D.S.
D.W.
LENGTH OF DUODENAL POUCH LESS THAN 35 CM.
DOG WILL LIVE IF ENTERO-ENTEROSTOMY TRIANGLE BE
STABBED SO AS TO PROVIDE DRAINAGE FOR THE POUCH.

In the second place, it was found that the length of the loop from the pylorus to the invagination was the essential factor in determining whether or not the animal would live. It was shown after many tests that if the distance from the infolding to the pylorus was less than 35 centimeters, it would die before

the twine triangular stitch gave drainage (70 to 100 hours). If the loop were longer, the animal would live.

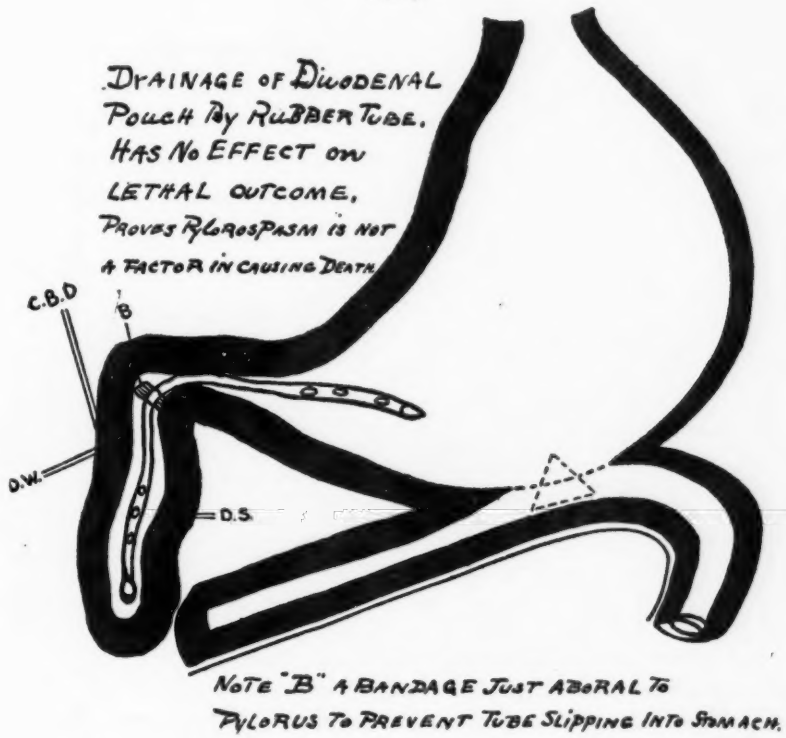
The third point is this: It was suggested by Dr. Flexner that this pseudo-tetanic death might be ascribed to decomposition of food materials in the stomach and duodenal loop. A number of experiments, however, upon fasting animals demonstrated that the presence or absence of food material in the stomach had no effect whatsoever in modifying the influence already alluded to of length of loop. Animals with stomachs well filled and those with alimentary canals thoroughly emptied showed no variation whatsoever in character or rapidity of death. The lethal line in either case was always approximately 35 centimeters from the pylorus.

There was a fourth point of importance. The question arose: Was the disturbance of innervation at the pylorus responsible for the death of the animal? A series of six dogs were operated on in the following manner. The pylorus was either sectioned or resected together with a small amount of stomach, and the ends infolded, great care being taken not to injure the bile duct. Twine triangular ligature was then inserted to create a gastroenterostomy. Without exception these animals lived until after the stoma had been established. This led to a most important conclusion. It showed that if the section and blockage of the duodenum were made oral to the bile duct, so that drainage were maintained for hepatic and pancreatic secretions, the animal would tolerate the absolute closure of the stomach without any ill effect until this viscus were drained by the establishment of the stoma 70 hours later. It is of great import to notice this, for it shows that, the nervous element owing to shock produced by section of the gut in the neighborhood of the pylorus, which has long been recognized to be a serious factor from a vital standpoint, in all operations in this neighborhood has absolutely nothing to do with this form of death which we have described as pseudo-tetanic. It suggests that the biliary or pancreatic secretions, or both, stand in some very definite relation to the lethal results observed. Pseudo-tetanic death occurring so constantly after section aboral to

these ducts and so rarely when the section was made oral to them, is indicative that some profound interruption of normal chemical processes in the intestine produces the fatal result rather than any nervous disturbance or shock.

It should be emphasized that the animals will live with a blocked loop less than 35 centimeters in length if the stoma be made an open one. Drainage of the stomach into the intestines

FIG. 4.


DRAINAGE OF DUODENAL POUCH BY RUBBER TUBE. HAS NO EFFECT ON LETHAL OUTCOME. PROVES PYLOROSPASM IS NOT A FACTOR IN CAUSING DEATH.
C.B.D
B
D.W.
D.S.
NOTE "B" A BANDAGE JUST ABORAL TO PYLORUS TO PREVENT TUBE SLIPPING INTO STOMACH.

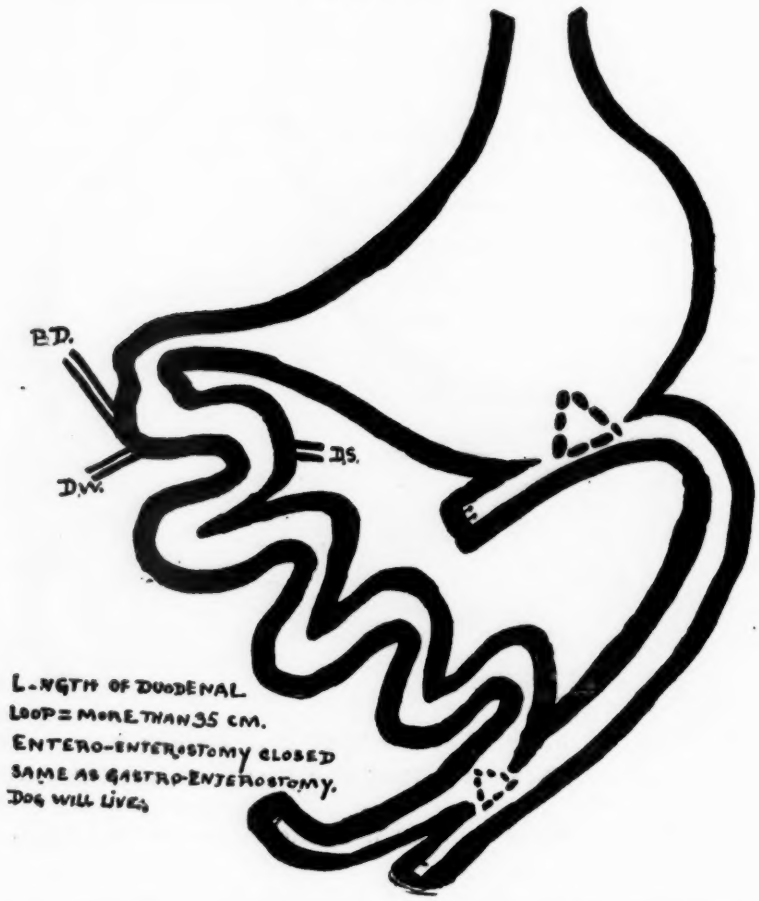
suffices to save the animal's life, no matter where the duodenum may be blocked.

It was further determined that the effect of entero-anastomosis between the jejunum just distal to the gastroenterostomy and the closed duodenal loop just aboral to the entrance of the ducts gave a similar result. Dogs operated on in this manner live. In other words, drainage of the loop is as

effectual in preventing the lethal results as is drainage of the stomach.

Moreover the fatal outcome is not the result of a closure of the loop produced by pylorospasm. The figure (4) shows how the proof of this was obtained. Rubber tubes placed so

FIG 5.

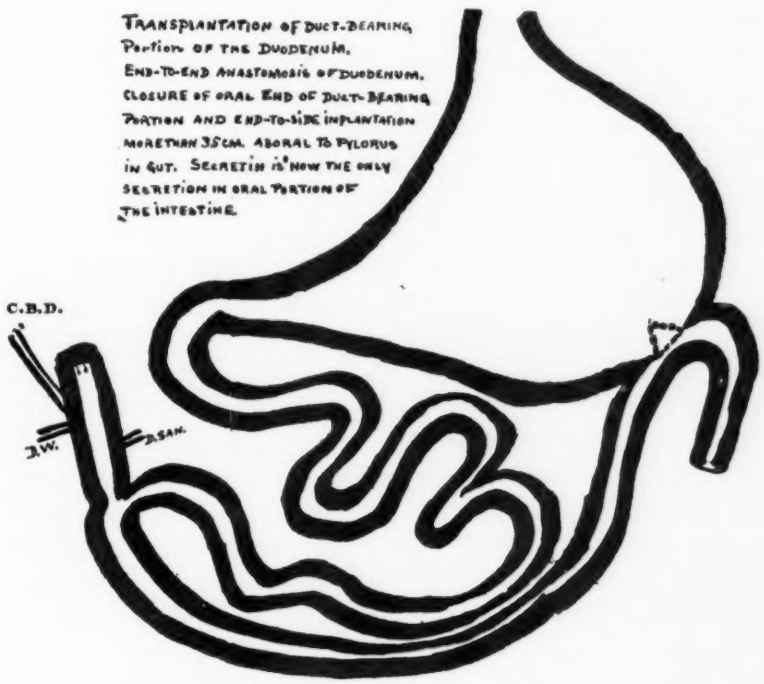


as to connect the loop with the stomach failed to be instrumental in preventing death. Drainage of the loop into the stomach is therefore shown to be without effect in preventing death.

Having eliminated nervous shock, as the source of lethal

impulse, as well as poisoning from food decomposition, obviously it became evident that the cause of death might lie in the production of poisonous substances produced by a mixture of the biliary and pancreatic secretions. It seemed possible, moreover, that this hypothesis might give us the real explanation of the fact that 35 centimeters or more of intestine in the closed duct-bearing portion sufficed to avert fatal results. For we may conceive that in this length of intestine such a quantity

FIG. 6.


TRANSPLANTATION OF DUCT-BEARING PORTION OF THE DUODENUM.
END-TO-END ANASTOMOSIS OF DUODENUM.
CLOSURE OF ORAL END OF DUCT-BEARING PORTION AND END-TO-SIDE IMPLANTATION MORE THAN 35 CM. ABORAL TO PYLORUS IN GUT. SECRETIN IS NOW THE ONLY SECRETION IN ORAL PORTION OF THE INTESTINE.
C.B.D.
D.W.
D.SAN.

of diluting material may constantly be furnished as would be adequate to render harmless the mixture alluded to. This supposition seems to be corroborated by the recent discovery of Flexner that the biliary salts, unless in colloidal suspension, act as violent poisons. He states (Jour Exper. Med., 1896, p. 174) that the conclusion may be drawn that the suspension of bile in a bland mixture of high colloidal strength protects

the pancreas from the immediate and acutely injurious action of the biliary salts."

Further, on page 167, he continues: "Bile contains two sets of constituents of highly different chemical composition crystalline principals and colloids. The biliary salts are known to act injuriously upon the cells while no direct cellucidal property is known either for the biliary coloring matter or the mucin."

None the less convincing as to the toxicity of the bile are the studies of Meltzer and Salant. They state: (Jour. Exper. Med., 1906, 8, p. 159) "We have positive and direct proof that normal bile from many rabbits possesses an exciting element capable of producing chronic convulsions in frogs." Page 165, "that contrary to the prevailing opinion, bile contains a tetanic element or an agent which causes increase of excitability of the nervous system. That stagnant bile as in the gall bladder, etc., invariably produces coma and paralysis, that the depressive and exciting elements of the bile are mutual antagonists; that the depressive element when present in a highly effective dose is by far the stronger of the two, while on the other hand the tetanic element becomes effective apparently in a dose far below that which constitutes the minimum for the depressive element. That bile salts seem to contain the tetanic element in an extremely less amount than the whole bile."

Moreover and also in support of the supposition that a true auto intoxication from biliary or pancreatic products is responsible for death in high intestinal obstruction, we quote from *Opie* (Diseases of the Pancreas). He showed by a long series of experiments that the introduction of bile into the pancreas caused either death of the animal within twenty-four hours or widespread destruction of the gland depending upon the amount of bile injected.

As a means of further study of this question, Dr. Blake suggested the possibility of transplanting the duct-bearing portion of the duodenum into the intestine at varying distances from the stomach. This is accomplished by means of section between the bile duct and the pylorus of the first portion of the

duodenum and a second section of the duodenum aboral to the entrance of the duct of Wirsung. The segment of gut thus removed is carefully sponged out and wrapped in hot cloths. The ends of the pylorus and duodenum are then united by end to end suture. More than 35 centimeters aboral to the pylorus an end to side implantation of the segment is done, the oral end beside the bile duct having been carefully invaginated. This is a difficult operation, but it can be brought to successful issue. Dogs emaciate quite rapidly after it has been done, so that the most recent operations practised have included a section of the intestine just aboral to the implantation of the duct bearing segment, and a gastroenterostomy by means of the triangular stitch between the stomach and the gut aboral to the section. This, it will be noticed by consulting the figure, produces the same results from an operative standpoint as is shown in Fig. 1, except that the loop of intestine from the bile duct to the pylorus is more than 35 centimeters in one case, while in Fig. 1, it is not more than 10 or 12 centimeters. These experiments are not as yet concluded.

A simpler method of testing the effect of the presence of the secretions would naturally be to tie the pancreatic ducts and the bile duct. This is easier from a technical standpoint, but of course it does not produce conditions in any way resembling the normal as does the transplantation technic already referred to. Nevertheless in a number of experiments, both the ducts of Santorini and of Wirsung have been tied as well as the bile duct. This series is not yet far enough advanced to enable us to make a report upon it. Some of the dogs have died and on autopsy the pancreas has been found to be exceedingly hard, while the omentum has been dotted with unmistakable areas of fat necrosis. This gross evidence of pancreatic lesion has not been observed in our cases of pseudotetanic death occurring after duodenal section and infolding just aboral to the ducts. It suggests therefore that the form of death in the one case may have been different from that in the other.

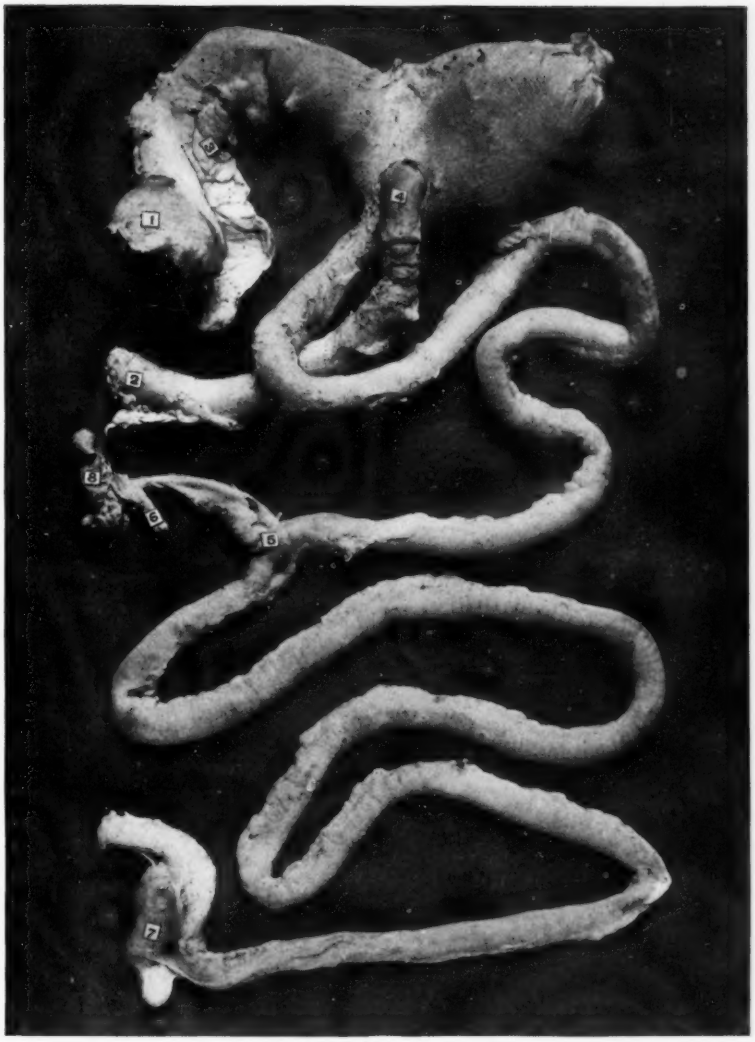
In another series of experiments, the bile duct alone has

been tied with two ligatures and divided between them. Here again the series is as yet too short to enable us to make any positive statements, but several dogs in which the bile ducts were cut, have lived with a short duodenal pouch and twine triangular stoma.

A method for transplanting the point of bile entrance beyond the 35 cm. line and one less difficult as well as less apt to be accompanied by adventitious pathological conditions such as fat necrosis is a simple chole cystenterostomy. This has the added advantage of separating the bile and pancreatic secretion. It is not easy to do this operation in two steps because of the formation of troublesome adhesions and done at one sitting, prolonged as it must be by gut section and infolding and by the triangular enterostomy, there is danger of death from shock or later by peritonitis from leakage. We have done two of these one-stage operations without a death by shock, but followed by fatal peritonitis on the fourth day. The third dog lived three weeks, and was killed to obtain the specimen shown in Fig. 7. It is immaterial that the animals died of peritonitis—the point of interest is that they survived beyond the time which would have been possible had the bile been passing down its normal channel.

MacCallum of Johns Hopkins who, with associates, has given us a most elaborate and exact study on ileus inclines to the belief that death is due to the absorption of bacterial toxines, which enter through the impaired gut wall. Clinically Mayo and others have confirmed this assumption by observing a lowered mortality to follow a wide resection of the dilated gut. Nevertheless it seems noteworthy, first, that total exclusions of gut segments may be made which, left in the abdominal cavity gradually grow to great size (see paper of Blake & Brown in this issue) without producing any signs of toxemia; second, that this work has been done in the relatively germ-free portion of the gut; third, that obstruction is tolerated during the cutting out of the control if placed oral to the bile duct while it always is fatal before the control cuts out, if situated aboral to it.

FIG. 7.



Photograph of specimen obtained from a dog in which acute duodenal obstruction was established. Cholecystenterostomy and twine triangular gastro-enterostomy and section of common duct were done at same time. Pancreatic ducts intact. Dog appears to have lived because of transplantation of the bile from duodenum into ilium. 1, Duodenal pouch. 2, Infolded aboral end. 3, Pancreas. 4, Site of stoma. 5, Cholecystenterostomy. 6, Cut end of common duct. 7, Cecum. 8, Remnants of liver. Mounted by Dr. Brown.

In conclusion it may be said that so far as our experiments go, there seems reasonable ground to believe that they demonstrate that death in duodeno-jejunal obstruction may be due to the absorption of toxic elements in the bile which are normally rendered harmless by dilution and colloidal suspension in the secretions of the small intestine. That as the length of small intestine from the bile duct to the site of obstruction decreases, so the diluting secretions decrease and the toxicity rises proportionately. That if further experimentation definitely proves that bile is directly the cause of death in certain forms of intestinal obstruction, it may be possible to lower the operative mortality. For a knowledge of the pathology of a condition is the first step toward the establishment of a successful mode of treatment.

STUDIES IN INTESTINAL EXCLUSION.*

BY JOSEPH A. BLAKE, M.D.,

AND

R. M. BROWN, M.D.,

OF NEW YORK.

From the Laboratory for Surgical Research, Columbia University.

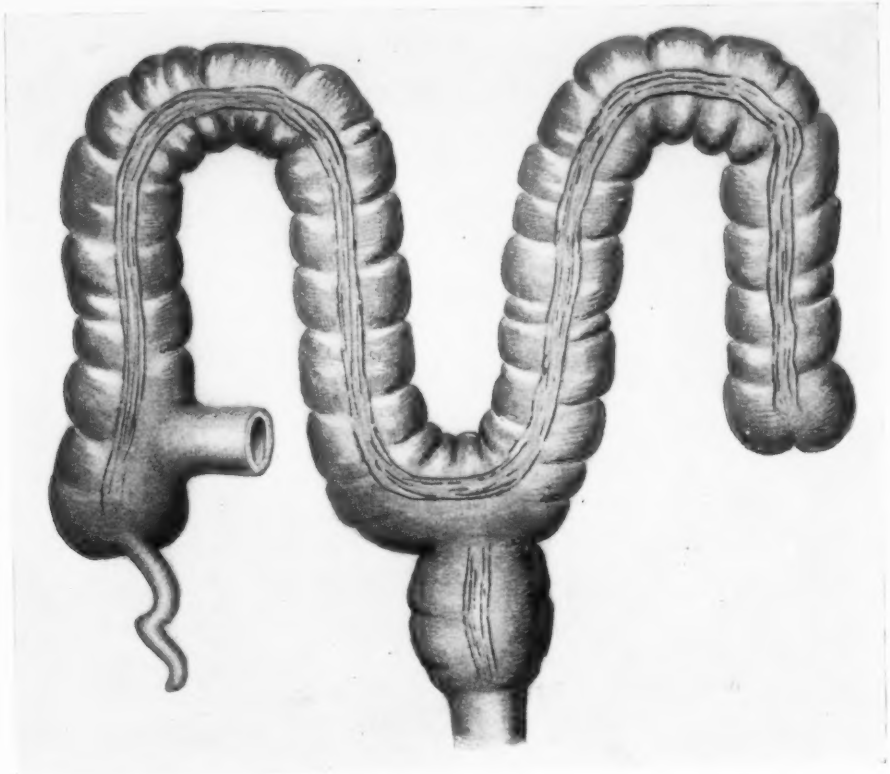
THESE studies were prompted by an operation upon a patient of one of the writers in whom, in order to reëstablish the continuity of the large intestine after the resection of the sigmoid flexure, an unusual anastomosis was employed.

The patient, a man fifty-six years of age, was operated on June 11th, 1906, for intestinal obstruction caused by what was supposed to be carcinoma of the sigmoid flexure but was afterwards proven to be hyperplastic tuberculosis. At operation the entire sigmoid flexure was found to be implicated in a mass which also invaded the bladder and the left spermatic cord. In order to remove it, it was necessary to sacrifice a portion of the descending and the upper part of the pelvic colon. The hiatus was so great that the ends could not be brought together without exerting undue tension, consequently the upper end of the remaining portion of the pelvic colon was implanted into the side of the middle of the transverse colon. This resulted in the formation of a blind pouch or cecum distal to the anastomosis (Fig. 1). The arrangement may be termed a unilateral aboral exclusion. It was recognized at the time to be faulty but the patient's condition precluded further interference and there was no certainty that it would provoke serious trouble.

The immediate convalescence from the operation was perfectly smooth and the patient gained twenty-eight pounds in the following two months. During this time he complained at times of colicky pains and there seemed to be accumulations of gas

* This and the eight accompanying papers by Drs. Eggers, Greene, Leggett, Maury, Blake, and Beer represent the results of studies conducted during the session 1906–07, in the Laboratory for Surgical Research, College of Physicians and Surgeons, Columbia University.

FIG. 1.



Implantation of oral end of remaining portion of pelvic colon into side of transverse colon. The portion of the colon distal to the anastomosis is aborally excluded.

and fecal matter in the excluded loop. This could be relieved by irrigations with a long rectal tube. Excision and division of the loop were considered but were not advised on account of the

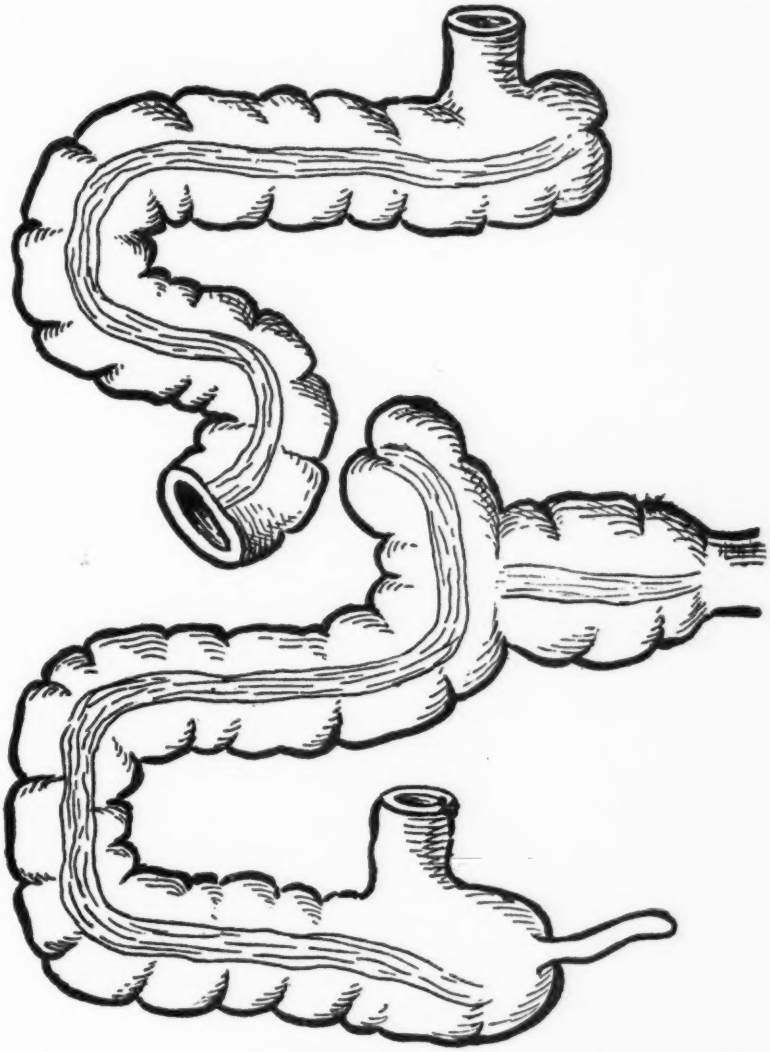


FIG. 2.—Showing arrangement after division of aboral segment and closure of proximal end. The totally excluded loop now communicates with the exterior at both ends; the distal opening being the one formed by spontaneous rupture.

continued improvement of the patient. In the meantime, he went to his home in a neighboring city and resumed his business.

During the winter the trouble from accumulation in the blind end increased necessitating daily irrigations and finally, at the end of January, 1907, perforation at the blind end occurred with the formation of an abscess. This was opened at Atlantic City. After remaining there for some weeks, he was brought to New York with a narrow sinus discharging pus, gas and fecal matter. The discharge occurred more or less intermittently and at times would be accompanied by sharp colicky pain due to the peristaltic efforts of the loop to empty itself. The patient's general condition was bad, he had lost much weight and was running a low grade septic fever. By increasing the drainage his condition was improved and on April 15, 1907, ten months after the first operation, the transverse colon was divided just distal to the anastomosis with the pelvic colon, the proximal end was closed and the distal end brought up into the incision (Fig. 2). The operation was exceedingly difficult on account of the adhesions. The loop now is a bilateral exclusion with a proximal opening; the distal end communicating with the skin by the fistulous tract. Water injected into the proximal end, escapes at once from the fistula but when injected into the fistula it does not escape from the proximal end, showing that it does not readily pass against peristalsis. Four months after the operation, the sinus communicating with the proximal end of the excluded loop barely admits a No. 12 French catheter and there is no discharge from it. The distal end is also open and communicates with a fistulous tract leading to the point where the intestine was closed just beyond the anastomosis. The discharge being mingled with a small amount of feces escaping from the latter its character and amount cannot be determined. However, as far as can be ascertained, the excluded loop has contracted so that it will hold only about an ounce of fluid.

The necessity for anastomosing the pelvic into the transverse colon seldom occurs. An extended search of the rather voluminous literature of intestinal anastomosis and exclusion failed to reveal a similar instance. As a rule, obstructing growths of the sigmoid flexure do not involve an extent so great as not to permit of end to end union after resection. Not having data derived from former cases and anticipating

FIG. 3.

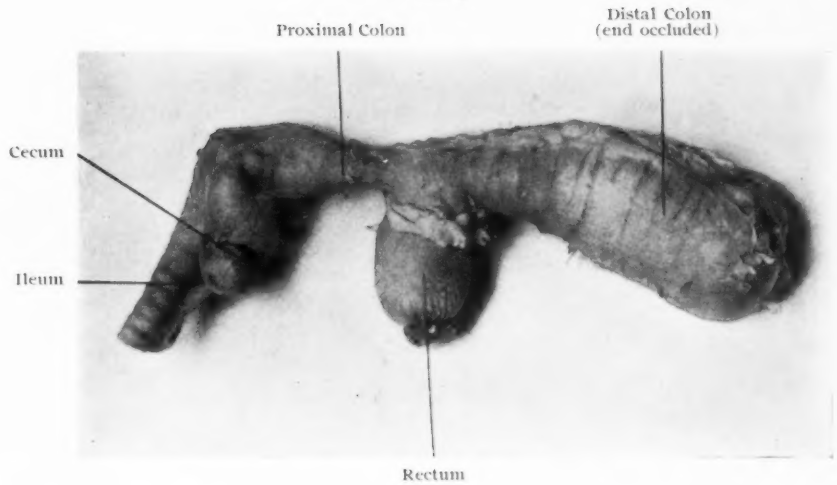
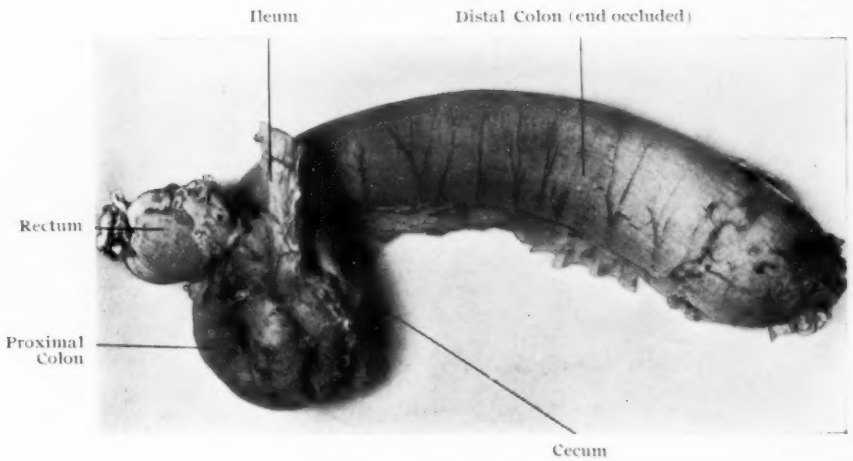
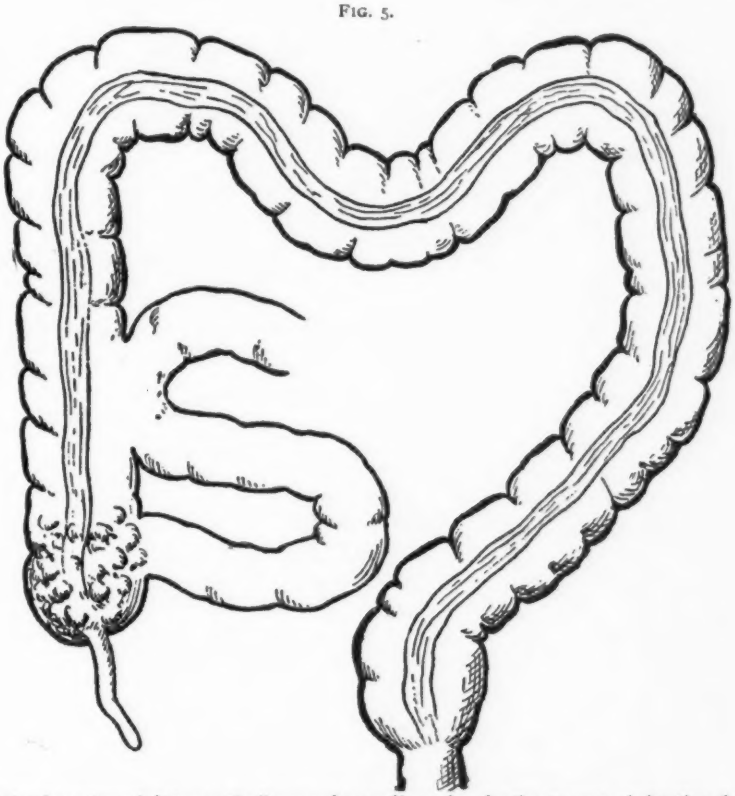

Proximal Colon
Distal Colon
(end occluded)
Cecum
Ileum
Rectum

FIG. 4.


Ileum
Distal Colon (end occluded)
Rectum
Proximal
Colon
Cecum

trouble from accumulation in the distal blind segment, similar operations were performed on dogs, the large intestine being divided just above the rectum, the oral end completely closed and the aboral end united end to side to the large intestine just distal to the ileocecal junction. The first dog was operated on November 19, 1906, and no adverse symptoms,

FIG. 5.



Lateral anastomosis between the ileum and ascending colon, for the purpose of shunting the intestinal contents by an obstruction in the cecum.

excepting a temporary diarrhœa, being noted, the operation was repeated on another on February 7, 1907. This dog also suffered from diarrhœa for several weeks after the operation. On April 27, 1907, both dogs were killed.

Examination of the blind intestine beyond the anastomosis showed that the intestinal contents had been crowded toward

the closed end dilating it to more than twice its normal diameter. Just beyond the anastomosis the diameter was practically normal which increased from there on to its maximum at the blind extremity (Figs. 3 and 4). After a greater

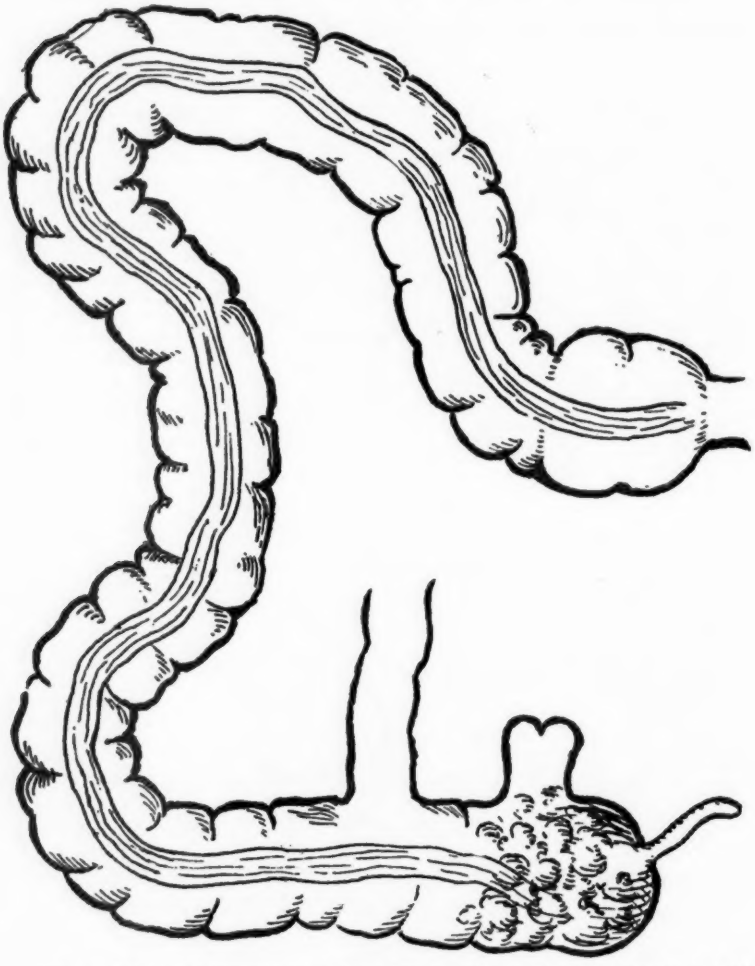
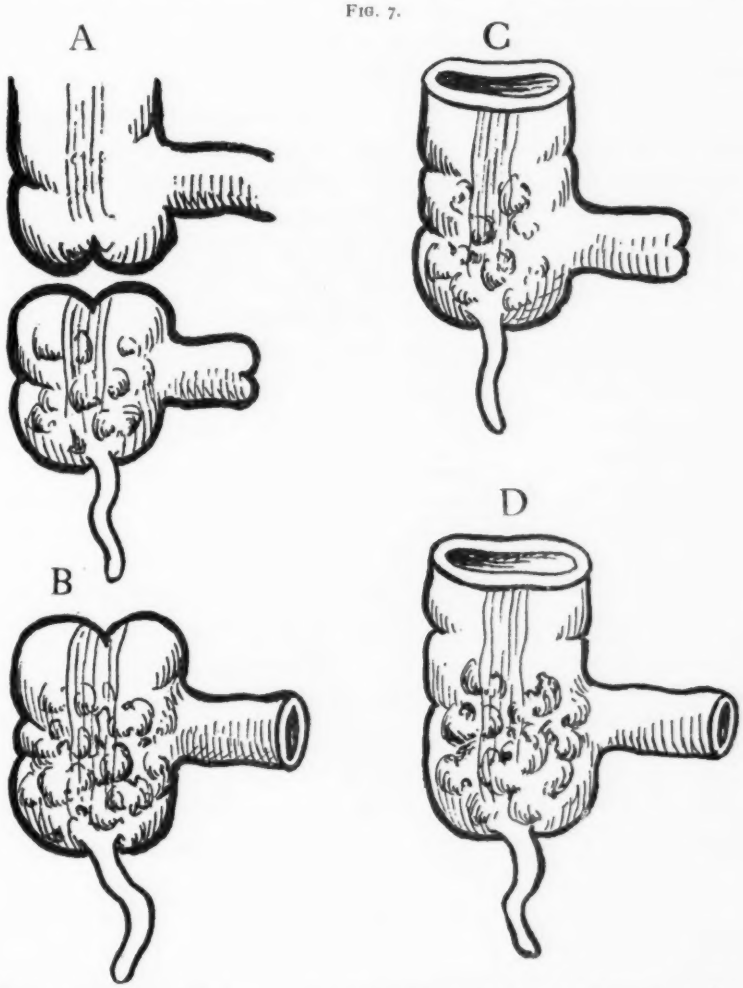


FIG. 6.—End to side implantation of ileum into ascending colon with occlusion of distal end of ileum. The segment comprising the distal portion of the ileum and the cecum is unilaterally or incompletely excluded and is unilaterally occluded.

lapse of time it is probable that perforation would have occurred in the dogs as it did in the man, either from ulceration or penetration by some foreign body accidentally ingested.

The results of the operation upon the patient and the dogs show that aboral partial exclusion of the intestine is a faulty and dangerous procedure. If the excluded segment cannot be

FIG. 7.



Bilateral or complete exclusion, with A, total occlusion B, dista. occlusion; C, proxima occlusion and D, both ends open and attached to skin.

excised, it should at least be totally excluded as was accomplished by the second operation in the case reported.

The objectionable features of such operations also apply to the ordinary lateral anastomosis performed to shunt the

intestinal contents by a diseased segment of gut. In such cases, if the obstruction is complete, accumulation occurs in that portion of the excluded loop which is proximal to the obstruction (Fig. 5). This objection has been recognized for a long time although its dangers have not been fully appreciated. In cases of fistula or when, for any reason, the presence of feces in the excluded loop is objectionable, lateral anastomosis is a complete failure inasmuch as the feces are not prevented from passing into it. For these reasons the end to side anastomosis resulting in a unilateral exclusion as recommended by Senn, is preferable (Fig. 6). Even when this operation is performed, fecal matter gathers to a certain extent, in the excluded segment on account of the double direction of the peristaltic movements in the large intestine, and if this is undesirable, complete exclusion as recommended by Salzer, should be performed; at least one end, preferably the distal, of the excluded loop being united to the skin (Fig. 7).

Unless one or both ends of a completely excluded loop communicate with the skin, or a communication exists by means of a fistula, troublesome accumulation is apt to occur. According to Reichel (Centralblatt f. Chirurgie, Bd. 22, S. 37) in experiments on animals, accumulation may or may not occur. Obalinski states (Centralblatt f. Chirurgie, Bd. 22, S. 129) that complete exclusion with total occlusion of the large intestine is safe but of the small intestine is dangerous on account of the preponderance of the secretory over the absorptive functions of the latter. According to Wiessinger (Deutsche Zeitschrift f. Chirurgie, Br. 62, S. 1) only one of four cases of complete exclusion with total occlusion was successful up to 1901, either rupture occurring with fistulous formation or death.

In order to determine the safety of complete exclusion combined with total occlusion of the large intestine, a series of five experiments were made on dogs. Two of the animals died of peritonitis immediately following the operation and the identity of one was lost leaving only two in which the result could be observed. One of these was killed four weeks

FIG. 8.

Photograph ⅔ natural size of completely excluded and occluded large intestine.

FIG. 9.

after the operation and the excluded segment was found to be distended with what was apparently fecal matter, to three times its normal diameter (Fig. 8). On section the walls were hypertrophic rather than thinned. The other animal was killed three weeks after operation and the result is well shown in Fig. 9. The photograph was taken one-half hour after the removal of the specimen and shows peristaltic contractions still taking place in the excluded segment. It is also interesting to note that the distal end is more distended than the proximal as a result of the peristalsis. The result of these experiments indicates that total occlusion, even of the large intestine is dangerous on account of distension of the segment by the excretions of the intestine. They also indicate that distal occlusion has the same effect upon the excluded loop as any obstruction has upon the intestine in general, namely, in increasing peristalsis and causing hypertrophy of the muscularis.

During the coming Winter further investigations will be carried out to ascertain the morphological and chemical nature of the semi-solid matter found in the excluded intestine. Its rapid accumulation is confirmatory of the theory that at least a large portion of the feces is excreted by the intestinal mucosa and that the function of the large intestine is not entirely absorptive.

ARE THE INTESTINES ABLE TO PROPEL THEIR CONTENTS IN AN ANTI-PERISTALTIC DIRECTION? *

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AND

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OF NEW YORK.

In the following pages we wish to bring together some of the evidence in favor of an affirmative answer to the above query. The evidence in favor of such an anti-peristaltic movement is both clinical and experimental. How frequently under normal conditions such movements do occur in the human intestine remains to be determined by future investigation. Here we are concerned only with the question, can the intestines propel their contents in an anti-peristaltic direction?

That this question is not altogether simple is evident. That it is not settled will be readily gathered from the statements to be quoted from recent authoritative writers. In Wilms' book on Ileus just published (on p. 26) he states, "An anti-peristalsis, that is, an evident upward peristalsis driving the contents of the bowel towards the pylorus, and not towards the anus, does not occur." On the other hand, W. J. Mayo, American Journal of the Medical Sciences, January, 1907 (p. 4), states, "The normal action of the upper colon is anti-peristaltic except during defecation," and further, "Murphy has shown that salines introduced very slowly into the rectum will be absorbed with great rapidity, largely by reverse peristalsis to the cecum." These opposed views, recently expressed, show the need of further study along these lines, and we trust that the following array of evidence will convince

* From the Surgical Research Laboratory, College of Physicians and Surgeons, Columbia University. Presented in part at the New York Academy of Medicine, May, 1907.

many who at present agree with Wilms' in his statement of the case.

Before discussing the evidence gleaned from experiments in the laboratory, and from observations in the clinic, we must briefly analyze a phenomenon which in all probability does not concern this study. If some non-absorbable powder, such as carmine, be placed within the rectum of a patient with a colostomy opening, and smears be made from this artificial anus, one will almost regularly find, in a shorter or a longer time, granules of this powder. In other words, this carmine has wandered from the rectum up the bowel and out through the colostomy wound. This curious phenomenon can be observed by any one in such clinical material as above referred to, or in laboratory animals if desired. At first blush it looks like an affirmative reply to the question before us, for the contents of the rectum have wandered upwards in an anti-peristaltic direction. Perhaps in due time this phenomenon may be adequately explained. At present almost all investigators are inclined to interpret this upward wandering of carmine from the rectum to the colon, or even to the stomach or higher, as due to upward currents along the intestinal wall, quite independent of peristalsis. The fact that this phenomenon occurs despite stenoses of the bowel, the carmine wandering through these rigid parts, and the fact that intestinal quiet favors the ascent of the carmine seem to exclude this from the group of phenomena which point to the possibility of anti-peristaltic activity in the intestine. The final verdict, however, has not been reached as yet.

Of direct bearing on the question before us, are two groups of observations—the one gathered in the laboratory and the other in the clinic. Both are of great importance, and both must be analyzed carefully. The experimental work is the more important as the observations are fuller and perhaps more accurate, and these we shall take up first, leaving clinical evidence for later consideration.

There are two experimental methods of approaching the problem as to whether the intestine is capable of propelling its

contents in the reversed or anastaltic direction, and in our work, which has been in progress almost 1½ years, we have employed only one of these, and that which seemed to promise most to us. Instead of employing the method of direct observation of the unoperated bowel, with or without the use of the X-rays we have used the operative or functional method of testing the capacity of the intestine for working in the reversed direction, by resecting segments in the small and large bowel, turning them around, and sewing them in place in reverse position. If the bowel is capable of propelling food in the reverse direction, then this reversed piece of intestine will function isoperistaltically; in other words its normal downward peristalsis will give way from time to time, or altogether to what would, under normal conditions, be antiperistalsis. Thus we would acquire rather conclusive proof that the intestine is capable of doing anti-peristaltic work, of accomplishing what Wilms so recently denied.

This method of approaching our problem is by no means original, as in 1889, Kirstein attacked the question of antiperistalsis in just this way. Since his publication many others have repeated his experiments (Mall, Edmunds and Balance, Muehsam, Kelling, Kauders, Enderlen and Hess, Prutz and Ellinger), but the lack of uniformity in results has occasioned considerable confusion.

Wilms' recent statement that, "in the experiments of Prutz and Ellinger, who have again carefully analyzed the anti-peristaltic intestinal movements, it is conclusively proven that the reversed segment shows the same peristalsis as before reversal, and that no real anti-peristalsis develops," fails to throw any light on this subject; in fact in our opinion, adds to the difficulties already existing. A brief review of the published work, and a careful analysis of Prutz and Ellinger's experiments will show, we believe, how erroneous Wilms' conclusion is.

In our opinion, the most satisfactory method of arriving at well-founded conclusions in these reversal experiments is by the direct study of the behavior of the reversed loops. That

is the only sure way of deciding in which direction the peristaltic waves progress. A second, but less accurate and decidedly inferential method of arriving at valid conclusions, is that in which reversals of extensive segments of the bowel are made. In such animals, regular defecations must be the sign of downward or katastaltic waves, as one cannot conceive of the intestinal contents traversing very large segments of reversed bowel towards the anus, unless the peristaltic waves propel them in that direction.

With these two methods and view points in mind, let us briefly review the work done along these lines, and then take up our own experiments which were done in part by ourselves, and in part by the students of the College of Physicians and Surgeons under the careful supervision of Dr. Maury.

A. Kirstein [1]—1889—operated on two dogs, reversing segments of the small intestine. He attempted a direct study of the peristalsis in one of his animals, but his attempt was unsuccessful. He noted at autopsy, the animals being killed 7 weeks and 3 months, respectively, after the operation, that at the upper anastomosis there was a spindle shaped dilatation with hypertrophy extending above and below the upper end to end anastomosis, and bisected by this. This dilatation he explained as the result of the two peristaltic waves working against each other. He concluded, with perfect propriety, that the peristalsis in the reversed gut must be reversed at least from time to time, to allow of the downward passage of intestinal contents through a reversed segment, which was ¼ of the length of the total small bowel, as in his second experiment.

Mall's [2] work was done about the same time as Kirstein's. He also found that at the upper anastomosis there regularly developed dilatation and hypertrophy, and that in this spindle shaped area, hard foreign bodies tended to collect, though some glass balls fed to such an animal passed through the whole alimentary tract. Faradic stimulation (2 mos. p. op.) in one

[1] Deutsche Medizinische Wochenschrift, p. 1000, 1889.

[2] Johns Hopkins Hospital Reports, p. 93, 1896.

case in which he employed it, showed no reversal of the peristaltic waves.

F. Kauders [3]—1893—repeated these reversal experiments in cats, but failed to obtain any adequate results from his study of the peristalsis of the reversed loop, as only the circular muscle fibres contracted. He thought that Kirstein's conclusions were incorrect, that the bowel contents were squirted through the reversed loop which was passive. He made this more than bold criticism despite the fact that in Kirstein's case (No. 2) ¼ of the small gut was reversed. To imagine a force adequate to squirting food, etc., through ¼ of the length of the small bowel, requires more than an ordinary effort.

W. Edmunds and C. A. Ballance [4]—1896—repeated these reversal experiments, and though their work throws no light on the question of anti-peristalsis, they call attention to the fact that the reversed loop became shorter in their cases.

G. Kelling [5]—1900—published one reversal operation in the uppermost jejunum. Three and one-third months after this operation he opened the animal's abdomen, and made a more or less satisfactory study of the peristalsis of the reversed loop. He incised the lower end of the loop, and saw the contents moved towards the rectum by distinct peristaltic waves! This animal was alive and well 1⅓ years after the operation.

Muehsam [6]—1900—contributed a great deal to this subject by bringing further evidence based on the second method of studying this problem—evidence along the same lines as Kirstein's, but perhaps more conclusive. He reversed practically all the small gut (430 cm. out of 485 cm.), and the animal lived 22 days, having occasional attacks of vomiting, and regular defecations. In the defecations, he recovered charcoal which had been fed by mouth 18 hours earlier. This unique case can in our opinion, be explained in only one way, by a reversal of the peristalsis in the reversed intestine.

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[3] Centralblatt f. Physiologie, p. 222, 1893.

[4] Medico-Chirurgical Transactions, London, vol. 76, 1896.

[5] Langenbeck's Archiv., p. 326, Bd. 62, 1900.

[6] Mittheilungen aus d. Grenzgebieten d. Medizin u. Chirurgie, vol. 6, 1900.

(*Prutz and Ellinger* try to explain the phenomena here observed as the result of the action of the surface currents originally described by Grützner, to which reference has been made above.)

In 1901 *Enderlen and Hess*[7] experimented along these lines, and in one case made a study of the peristalsis in the reversed loop. By faradic stimulation, a peristaltic wave was produced in the reversed direction from normal, *i.e.*, the peristaltic wave was reversed in the reversed loop.

In 1902, Prutz and Ellinger[8] reviewed the whole subject, and did further experimental work along the same lines. In one case they observed the peristalsis in the reversed loop, 31 days after the operation, and found that it was not reversed. They admit, however, that occasionally anti-peristaltic (reversed) waves were seen in the reversed, and in the non-reversed bowel. In all their 12 experiments this is the only observation or study of the peristalsis of the reversed loop. They, however, attempted to determine by other means, in which direction the peristaltic wave progressed. By producing a stenosis in the lower part of the reversed loop, and noting on which side of this, dilatation developed, they thought they could discover the direction of the wave. Thus if the peristalsis were reversed, dilatation would occur above the stenosis; if not reversed, dilatation would develop below the artificial stenosis. In 2 cases they obtained results which they interpret as showing no reversal of the peristaltic wave. In our opinion, they have gone beyond the data which they have published, and to us it seems as if their conclusion was not only unwarranted, but in view of the fact that the dilatation above the artificial stenoses was regularly much greater than that below, a conclusion, the direct opposite of theirs, seems justifiable.

This brief review shows how at variance the different results are. Most of the experimentors failed to study the peristalsis in the reversed loop. Some attempted such a study, but invariably only in one case. This most conclusive method of

[7] Deutsche Zeitschrift f. Chirurgie, p. 240, 1901.

[8] Langenbeck's Archiv., p. 964 Bd. 67, 1902.

deciding the problem before us has been signally neglected. The second method of investigating this question, Kirstein and Muehsam used successfully by making very extensive reversals.

In our work done on dogs, some 20 experiments in all, we employed both methods of investigation, and our results will be grouped according to the method employed. We operated in the usual way, cutting out a segment of small gut or large gut and then reversing it. The anastomoses were either end to end, or lateral. The latter was preferable when very large segments were reversed, as there was apparently, less direct tension on the suture line by opposed peristaltic waves, and consequently less chance of leakage. No matter how carefully the operation was done, leakage and separation at the upper anastomosis would occasionally develop so that we were inclined to conclude that the bowels of different dogs varied in their irritability, and perhaps in their muscular strength to such a degree that the technique that was adequate for one might prove inadequate for another, when the opposing and perhaps obstructive peristaltic waves caused undue pressure against the upper anastomosis. At the lower anastomosis, such leakage was most exceptional despite the fact that the direction of the peristaltic waves was probably in opposite directions, *i.e.*, tugging at the anastomosis.

In all animals that survived the operation, we did not make studies in peristalsis, as we were interested in other problems connected with this work, and did not wish to sacrifice all to this study. In the following pages we trust, however, we have sufficient data to warrant the standpoint we have taken.

SERIES I.—*Direct Inspection of Reversed Loop—Small Intestine Reversals.*

No. 84.—Spaniel operated March 15, '06. Median abdominal incision. Reversal of about 15 inches of lower ileum and lateral anastomoses in reversed position, to the bowel above and below lines of section.

March 20. After primary indisposition animal recuperated on diet of milk and biscuits.

May 20. Defecates regularly (practically daily; careful note of this being made every day). Animal began to do poorly.

June 9. Eleven weeks after the reversal a study of the peristalsis was made under ether, the intestines being well protected by very frequent use of warm saline solution, hot towels, etc. The peristaltic waves were stimulated in a variety of ways, mechanical, chemical and thermal stimuli being employed in the different experiments.

Observation.—The peristaltic wave in the reversed loop was very clearly in the same direction as that of the rest of the small bowel. Peristaltic waves that began above upper anastomosis traveled into the reversed loop and then down this across the lower anastomosis. Peristaltic waves which began in the reversed loop traveled to a slight extent upward, but in the main they traveled downward and then frequently across the lower anastomosis.

Autopsy showed in addition to some adhesions which produced slight kinking of the bowel, well marked dilatation and some hypertrophy of the lower end of the gut above the upper lateral anastomosis. The reversed piece was very slightly dilated and contained two large fecal masses.

No. 41.—Fox terrier had been frequently operated, *i.e.*, gastroenterostomy, gastrotomy before reversal was done.

March 8. After breaking up a lot of adhesions 24 inches of lower ileum were reversed and united to the rest of the bowel by end to end anastomoses.

April 1. Animal except for occasional vomiting did fairly well. By adding milk to his biscuit diet his condition was improved. Defecates regularly.

April 24. Six weeks and five days after the reversal the abdomen was opened to study the peristalsis as in the previous case. The exposure was difficult because of adhesions.

Observation.—The bowel proximal to the upper end to end anastomosis was found markedly dilated and hypertrophied for 6–8 inches. The upper part of the reversed gut for 1–2 inches was similarly changed. The rest of the reversed bowel—the lower anastomosis and the bowel below were unchanged. The reversed loop was empty, whereas the parts adjacent to the upper anastomosis were full of intestinal contents. In studying the peristaltic waves great difficulty was met with in determining which way they progressed. Above the upper anastomosis the wave was katastaltic, *i.e.*, in the normal direction, while in the reversed loop mechanical stimulation as well as heat evoked once a peristalsis in one direction and at another time in the opposite direction. In the lower part of the reversed loop the direction of the peristaltic wave was more distinctly downward. Abdomen closed.

May 12. Nine weeks and two days after reversal, abdomen again opened for peristaltic study.

Observation.—After separating adhesions in abdomen, we attempted to stimulate peristalsis without any further manipulation of the bowel. Croton oil was injected into the lumen without results; local application of salt produced only localized circular contractions. Hot saline solution produced well-marked peristaltic waves, which could be seen beginning above the upper anastomosis, traveling across this anastomosis and con-

tinuing down the reversed gut. In this loop the circular muscle contractions were well marked. The progression of the peristaltic waves were distinctly from upper to lower anastomosis. The bowel was almost empty. Animal killed.

No. 90. Pug. On March 22d between 12 and 15 inches of lower ileum were reversed and end to end anastomoses (Maunsell method) were made. The dog was carefully fed on milk, meat and biscuits so that he might continue in good health for a long time.

October 23. Seven months after the reversal the abdomen was opened.

Observation.—There was marked dilatation above upper union for at least 15 inches. This piece of bowel was also hypertrophied. In the region of the upper anastomosis there was an accumulation of stones. The reversed loop was slightly dilated and markedly hypertrophied. The peristaltic waves were distinctly downward in the reversed loop.

SERIES II.—*Colon Reversals.*

No. 76.—On March 10, 1906, as much of the ascending colon as could be liberated—about 6 inches—was resected and reversed and then reunited by end to end anastomoses to the rest of the bowel. This case did well on the selected diet.

January 4, 1907. Almost ten months after operation the abdomen was opened and a study of the peristalsis was made.

Observation.—The reversed loop was dilated and hypertrophied. The peristaltic waves descend from the ileum across the upper anastomosis and then descend through the reversed loop, but stop at the lower anastomosis. Circular contractions follow each other in the reversed loop, in the same direction as the composite peristaltic wave. The reversed bowel contains foreign bodies.

These observations of the behaviour of the reversed loops leave no doubt in our minds that the small and the large bowels are capable of propelling food in an anti-peristaltic direction. It would appear that the bowel has a distinct power to work in an anti-peristaltic direction and moreover that this power is capable of extensive development. Early in the life of the reversed loop, there seem to be ana- and kata-staltic waves; later on the kata-staltic (which are anti-peristaltic with reference to the original normal bowel) seem to predominate. We are inclined to agree with Kirstein, that in the reversed loop, the peristaltic waves vary in direction, especially at an early stage in the life of the reversed loop, and that is well shown by Case 41, at the first study of peristalsis. Prütz and Ellinger's observation of anti-peristaltic alternating with isoperistaltic waves in their one case, seems to us to fit into this view

of the matter. Perhaps Mall's observation will bear a similar interpretation which harmonizes the divergent results summarized above. To what extent the reversed bowel moves kata-staltically with abdomen closed, we can not say as yet.

Just why a more or less spindle-shaped dilatation develops at the upper union is not very clear to us. At first one would jump at the explanation usually offered—that there is an obstruction due to opposed peristaltic waves and that leads to dilatation and hypertrophy at this point.[9]

That some truth is contained in this explanation, in view of the fact that foreign bodies tend to collect in the lumen at this point, and in view of the observation made by Cannon and Murphy mentioned further on, we can not doubt, though we feel sure it is not the complete explanation, as the same obstruction would, we think, be manifested throughout the length of the reversed loop, still the loop as a whole does not dilate and hypertrophy.[10]

If we now turn our attention to the second or inferential method, *i.e.*, the reversal of very big segments of the bowel, we find that with reversal of the whole jejunum and ileum, most animals die of a perforative peritonitis due to leakage at the upper union. Those animals that live long enough to be of any value, behave much as Muehsam's case, defecating repeatedly after the first day or two, without any marked vomiting. These animals, probably because of the great change in the intestinal chemistry, digestion and absorption being rudely interfered with, die very suddenly. For instance, one animal thus operated on did well in every respect for five days and then died suddenly without any definite gross lesions to demonstrate the cause. Another died suddenly 10 days after operation, a few hours after receiving a good dose (½ ounce) of castor oil. This animal at autopsy had a fresh invagination at the lower anastomosis which occluded the bowel.

[9] The fact that this dilatation develops very early lends support to this view.

[10] The colon may behave differently from the small intestine—the whole loop apparently dilates and hypertrophies here.

But it is not necessary to rely on such extreme cases alone. It is sufficient to reverse some 15–24 inches, as we did in a large number of cases. For it is inconceivable that an animal can defecate regularly, if such a length of reversed bowel does not, at least from time to time, function kata-staltically. In the cases quoted above, such resections have been made and the animals lived in fairly good health and defecated practically every day, provided they were carefully fed. To cite further cases, from our lists, of prolonged life with regular bowel activity after such reversals would not be of any value. We regret that we could not duplicate Muehsam's case and keep an animal, with reversal of all the small intestine, alive for over three weeks.

Thus both groups of observations point to the conclusion that the intestines both large and small, are able to propel their contents in an anti-peristaltic direction.

Further evidence of the truth of this conclusion is furnished by the excellent observations of Cannon andMurphy,[11] who observed anti-peristalsis in the duodenum, a portion of the intestine that we could not experiment on. In a reversal experiment, where the jejunum was reversed close to the duodenum, they repeatedly saw, 6 days after operation, with the aid of the X-ray, that food left the pylorus and descended to the upper anastomosis and then was in part rapidly moved back again towards the pylorus. This unique observation makes it equally clear that there is a more or less marked obstructive condition at the upper anastomosis in these reversal experiments.

Cannon's earlier work on the peristalsis of the ascending colon of cats, shows without a doubt that Jacobi's[12] observation of anti-peristalsis in this part of the bowel (and in lower ileum in colchicin poisoning) was well founded. Here it would seem that this is a normal process,[13] whereas our ex-

[11] ANNALS OF SURGERY, 1906.

[12] Archiv. f. Exp. Pathologie u. Pharmakologie, vol. xxvii, 1890.

[13] Except in dogs. T. R. Elliott and E. Barclay Smith, Journal of Physiology, xxxi, 1904, p. 273.

periments do not take us that far, any more than those well known experiments of Nothnagel, in which he produced anti-peristalsis in the bowels by abnormal stimuli, such as injections of concentrated salt solution.

In addition to all this experimental evidence, we dare not disregard the clinical evidence which so frequently has to be taken with a grain of salt. In this paper we shall not go into this matter in any great detail, as our main object was to present our experimental results; still for completeness sake we must briefly mention the clinical evidence in favor of an affirmative answer to our postulated query, at the head of this paper.

Fecal vomiting in intestinal obstruction and the vomiting of fecal masses and enemata in so called hysterical patients, excluding of course actual cases of fraud can be most readily explained by this ability of the bowel, especially marked under abnormal stimuli of propelling their contents in an anastaltic or antiperistaltic direction.

These two types of fecal vomiting must be distinctly separated, as the former is explicable in several ways whereas the latter in our opinion is subject to but one explanation. In the vomiting of intestinal obstruction, the fluid contents of the bowel may be squeezed out of the bowel into the stomach, thence to the outer world by the pressure exerted by the forceful contractions of the abdominal muscles—anti-peristalsis may have nothing to do with it. Cannon and Murphy's observation, above referred to, makes us believe however, that anti-peristalsis is an important factor in this process, the more so as all of the bowel above an obstruction is not regularly well filled at autopsy of ileus cases, as the explanation based on hydrodynamics would demand. It appears to us, therefore, that both forces work together in producing this symptom.

The vomiting of formed feces and the vomiting of enemata a few minutes after introduction into a normal alimentary tract, as reported by Treves, Langmann [14] and others,

[14] A. Jacobi, Festschrift, 1900, N. Y.

cannot be explained by anything short of a most active antiperistalsis of the whole bowel. In this we consider Nothnagel's verdict final, despite Wilms' recently expressed scepticism. The former says in his discussion of those cases, so called hysterical ileus cases, " that in no other way can this vomiting be effected than by well marked, in part even very active antiperistalsis of the intestine."

RECTAL ANÆSTHESIA EXPERIMENTAL STUDIES TOGETHER WITH A REPORT OF ITS PRACTICAL EMPLOYMENT AT ROOSEVELT HOSPITAL.

BY NOEL BLEECKER LEGGETT, M.D.,

OF NEW YORK.

ETHERIZATION by rectum is by no means a new departure, for at different times in the past sixty years, methods have been sought whereby a patient might be anæsthetized by this method. Perigoff in his book on etherization published in 1847 mentions it. At the same time Roux in the Journal de l'Academie des Sciences, refers to the possible utility of rectal anæsthesia. Març Duprey employed ether pure or mixed with water as an injection for the purpose of producing anæsthesia. Malliere in 1884 used ether vapor obtained by boiling ether and letting the expanding gas force itself into the rectum. In the same year, Hunter reported six favorable cases. He praised the method, but did not mention any after effects. Weir (N. Y. Med. Rec., 1884, XXV, p. 507) gives seven cases reported by Dr. W. T. Bull, all of which had bloody stools following this method, besides two cases of his own, one of which ended disastrously.

Wanscher in the same year, 1884, records 22 cases of anæsthesia induced by injecting ether vapor into the rectum. All of his cases were favorable except one, in which he was unable to produce narcosis due to the presence of feces in the colon. But the next day after the colon was thoroughly cleaned out, the patient was readily anæsthetized. This shows the importance of having the lower bowel fully prepared before attempting narcosis (Congress Med. Sciences, 1884, p. 186, Sec. 1). Post reports three cases with no vomiting or diarrhœa (Boston Med. & Surg. Jour., 1884, CX, p. 442). Bux-

ton used this method and advocated its use for operations on the head, neck and for empyema.[1]

The method then lay idle from 1898 until two or three years ago when J. H. Cunningham of Boston again brought it before the public. He presented forty odd cases, all of which pointed to the practicability of rectal anæsthesia, if properly administered. Reading Dr. Cunningham's paper in the Boston Medical and Surgical Journal, it seemed, in view of his results with improved technic, that rectal anæsthesia had not had a full and fair trial in this city.

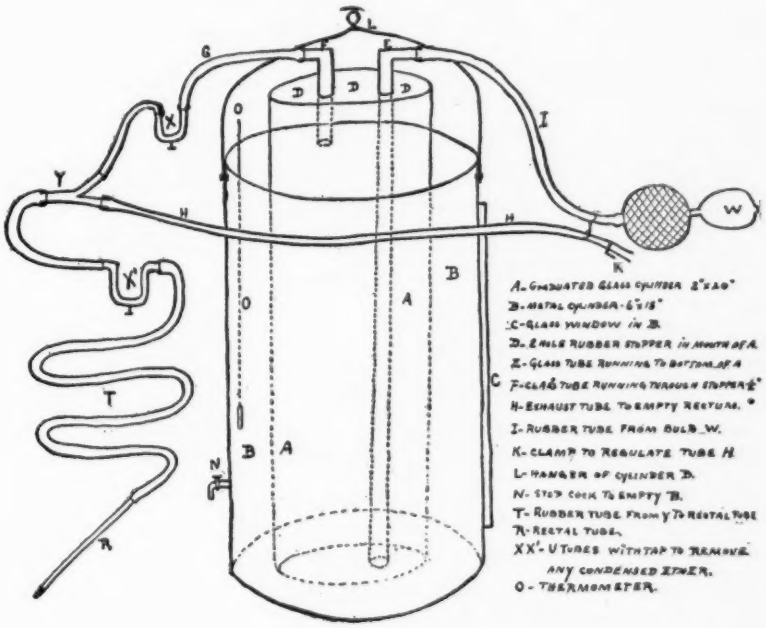
The method originally employed was that of boiling the ether in a vessel and allowing the expanding vapor to force itself into the rectum. In this way the vapor entered the rectum in such volume that there was a condensation in the tubes. Liquid ether was consequently forced into the gut, causing extreme irritation, ulceration and hemorrhagic proctitis.

Cunningham's method is somewhat similar, yet it varies in one vital point. The vapor of ether is forced into the rectum in such a way that there is no condensation, and absorption takes place with such rapidity that it is not possible for fluid ether to be forced into the gut. This is done by keeping the ether heated, yet constantly below 37° C. which is its boiling point, and forcing the fumes into the bowel by means of a rubber hand bulb. Herein lies the essential difference between the new technic and the old.

The apparatus is demonstrated in the accompanying cut. The effect upon the patient is as follows: He reclines in dorsal position with legs slightly flexed. The rectal tube is inserted 8 to 12 inches. Ether fumes are then slowly forced into the rectum. They cause a sensation of fullness so that the patient may have a desire to defecate. This is overcome by opening the exhaust tube at K and allowing the gases which are in the

[1] In 1898 S. J. Meltzer used ether by filling a bottle half full and placing it in a water-bath at a temperature above that of the rectum hot enough to boil the ether. He noted that ether is apparently more completely excreted when given by rectum than by the lungs.

rectum to escape. This should be repeated as often as may be necessary. It will immediately relieve any possible distress. The ether vapor is pumped in slowly, keeping the bowel comfortably full. The patient may have for a time slight discomfort, then becomes gradually drowsy and the odor of ether appears upon his breath. He falls asleep and in a comparatively short time has passed into full narcosis.


A- Graduated glass cylinder 2"x20"
B- Metal cylinder- 6 7/8"
C- Glass window in B.
D- 2 hole rubber stopper in mouth of A.
E- Glass tube running to bottom of A
F- Glass tube running through stopper
H- Exhaust tube to empty rectum.
I- Rubber tube from bulb W.
K- Clamp to regulate tube H
L- Hanger of cylinder B.
N- Stop cock to empty B.
T- Rubber tube from y to rectal tube
R- Rectal tube.
XX'- U tubes with tap to remove any condensed ether.
O- Thermometer.

This method has its faults and its merits—its uses and its abuses. It will at once be conceded that if it can be made as free from danger as anæsthesia by mouth and free also from the danger of hemorrhagic proctitis, there are many operations about the head and neck in which its employment would be most useful. Studies directed toward determining what proportion of the ether administered is eliminated via the lungs are under consideration at the Laboratory. With the completion of these, it will be possible to state positively how

advantageous this method will be in cases of tuberculous pulmonary involvement.

Our post operative observations upon the patient may now be considered. The nausea, which in the inhalation method is still present despite many technical improvements is greatly decreased and in many cases absent after rectal anæsthesia.

So far I have given rectal anæsthesia in human beings in 13 cases only. We have, however, employed it upon dogs during a considerable period of experimentation. In these animals, it produces no proctitis, and if the fumes are allowed to pass the ileo-cecal valve, complete narcosis may be maintained for any length of time. Dogs have too short a colon to lend themselves favorably to this study. Through the kindness and interest of the attending staff of Roosevelt Hospital, I have had the privilege of using this method on the following cases:

CASE No. 1.—It was one of cervical adenitis on Dr. Blake's service, operated upon by Dr. Martin; a boy, fourteen years old. Ether was started by the rectal method and in twelve minutes he became very heavy and drowsy, having had no discomfort whatsoever. After this, the patient muttered incoherently for a short time, then became quiet in 20 minutes after the ether was started and in 30 minutes there was absolute narcosis. The patient was under ether for 45 minutes during the operation, 85 minutes in all. The respirations were regular and full and there was none of the harsh rattling breathing due to bronchial secretions. The color was unusually good throughout the operation, and the blood was at all times well oxygenated. The patient made a rapid ether recovery, vomited once and had no rectal symptoms at all. Dr. Martin thought the blood did not coagulate as rapidly as usual.

CASE No. II.—Dr. Blake's service. Operated on by Dr. Martin—tubercular rib. This patient had tubercular conditions in other parts of the body. Had taken ether several times previously. Ether was started by rectum and in ten minutes the patient was drowsy, although he complained a good deal at the length of time consumed. In twenty minutes, he was completely

anesthetized. Breathing was regular, pulse good and strong showing the stimulus of the ether. Patient was under ether anæsthesia for thirty minutes in all. He made a quick recovery and had no rectal symptoms. He complained simply of the length of time taken in producing sleep. Said the method was free from pain.

CASE No. III.—Sacculated empyema. Operated upon by Dr. Blake. Anæsthesia was commenced both by inhalation and rectum, the patient being anesthetized in five minutes, then the ether continued by rectum during the operation, which lasted twenty minutes. The breathing was full and regular, color perfect and pulse all that could be desired. Rapid ether recovery with no rectal symptoms of any kind.

CASE No. IV.—Sarcoma of frontal sinus. Operated upon by Dr. Blake. Patient had had ether twice previous to this. Ether was started by mouth and rectum and in ten minutes the patient was completely anæsthetized, when the inhalation was discontinued, but ether continued by rectum. The patient began to come out before reaching the table, so inhalations were again given till complete narcosis was again obtained, when it was discontinued. The patient again came out, and anesthesia by mouth was continued for the rest of the operation. This case was one in which the rectal method was not effectual. It demonstrated, however, with the preceding, that the ether vapor has no ill effect upon the mucous membrane of the colon, for the patient came through with no colic or other untoward symptoms.

CASE No. V.—Dr. Blake's service. Dr. Martin operating. Cervical adenitis. Rectal ether started and given for ten minutes when patient became drowsy. The operator being ready, ether was given by mouth till the patient was anæsthetized, then anesthesia continued by rectum for one hour. The patient was in perfect condition throughout the whole of this time, made a good quick ether recovery with little vomiting and no rectal symptoms.

CASE No. VI.—Epulis. Dr. Martin operating on Dr. Blake's service. Ether began 12:15 by mouth and rectum. Patient under in five minutes when ether was continued by rectum for twenty-five minutes. Recovery with very little vomiting and no colon nor rectal symptoms.

CASE No. VII.—Hydrocephalus in a child three years old.

Operated upon by Dr. Brewer. Child was anæsthetized by mouth and rectum and then anæsthesia continued by rectum. Patient lost sensation in three minutes. The ether was continued for fifty minutes in all. At one time stimulants had to be given due to the shock of the operation as much as to any effect of the ether, if not wholly so. The child's ether recovery was rapid with some vomiting, but absolutely without any rectal irritation.

Case No. VIII.—Axillary Carcinoma. Operated upon by Dr. Blake. Ether was started by mouth and rectum. The woman was fully anæsthetized in a few minutes. Patient defecated while going under. As soon as inhalation was stopped, patient began to come out of ether, and it had to be continued by mouth. The patient defecated several times, at last clogging rectal tube, so ether had to be stopped by rectum. Colon had not been adequately cleaned.

This case shows that it is most necessary to have the bowel fully cleaned before the patient can absorb the ether rapidly enough to keep up complete narcosis.

Case No. IX.—Dr. Martin. Cervical Adenitis. Child—girl 5 years. Ether started by mouth and rectum. Patient anæsthetized in 3 minutes. Patient was under ether 30 minutes. The rectum being partially filled, it was difficult to regulate the anæsthesia. Patient defecated twice. Rapid recovery. Very little vomiting.

Case No. X.—Dr. Blake. Cervical Adenitis—boy 16 years. Ether started by mouth and rectum. Patient anæsthetized fully in 5 minutes. Then ether continued per rectum. Patient under 30 minutes. No bronchial secretions. Patient at first was hard to control but in a short time was fully in a lax and narcosed condition. Patient made rapid ether recovery with no vomiting and no rectal distress.

Case No. XI.—Dr. Brewer. Tubercular Laryngitis. Adult.
3.15 Morphine Sulphate, gr. ¼ given by hypo.

3.30 Ether by mouth and rectum. Ether continued by rectum 65 minutes; respiration, full, strong and regular; the pulse good.

Patient recovered from the ether rapidly with no rectal distress, and very little nausea or vomiting.

Case No. XII.—Dr. Brewer. Carcinoma of Face. Ether

commenced by mouth and rectum and continued by rectum alone for 20 minutes. Rapid and easily recovery.

CASE No. XIII.—Dr. Flint. Epithelioma of Lower Maxilla. Resection of Maxilla. Ether started 2.15 P.M. Patient on the operating table 2.35, when ether was continued by rectum until 3.20. Color of patient good; pulse slightly rapid; no condition of shock. Rapid ether recovery with very greatly decreased nausea and vomiting.

These cases, though few show in a small way the possibilities which this method of etherization offers, both to patient and to operator.

Rectal anæsthesia may thus be summed up from two standpoints, viz., from that of the patient and from that of the operator.

The lessening of nausea, the lessening of irritation to the lungs and the lessening of the bronchial secretions which were nearly entirely absent in most of the cases are certainly all in themselves favorable. Furthermore, a fully and continuously clear field of action in all operations about the head and neck saving time and loss of blood and above all lessening the chance of infection from an ether cone, are all points in favor of the method which must appeal to every operating surgeon.

The chief points about the apparatus which we believe to be new and useful are, first the introduction of the Y and exhaust tube to empty rectum and second the glass U tubes which enable one to be certain that no liquid ether is passing into the rectum. It is a convenience and a safeguard for the anæsthetist to be able to empty the rectum of gas or of ether vapor at a moment's notice.

Since sending the above to the publisher I have had the good fortune to collect through the kindness of Dr. W. S. Sutton, of the Roosevelt staff, eighteen additional records of the use of rectal anæsthesia at the hospital. This makes a total of thirty-one (31) cases.

Two of these recent records deserve particular attention.

In the first case the patient was markedly alcoholic and therefore a large ether consumer. After ether recovery he had one small rectal hemorrhage. The cause of this is unknown. All succeeding movements were blood-free.

In the second case, Dr. Chas. H. Reck operated for the removal of an enlarged thyroid. He was struck by the advantages offered by rectal anæsthesia in this class of cases and believed that under favorable conditions it might in time supplant the slower method of cocaine infiltration.

A large number of suitable cases are now being anæsthetized by the rectal method at Roosevelt Hospital, and when Sutton's conclusions are published we shall know quite positively the advantages accruing from Cunningham's new technic.

TUBERCULINS AND THE TUBERCULO-OPSONIC INDEX.*

BY THEODORE DUNHAM, MD.,

OF NEW YORK.

THE present paper is in no sense a review of the work done and results achieved in this interesting field. My aim is to present the subject to you as it has presented itself to me. I shall be thoroughly practical and shall discuss chiefly the method of determining the tuberculo-opsonic index as I am practising it, and the tuberculins.

In the *Deutsche medizinische Wochenschrift* for April 1, 1897, Koch described his improved tuberculin. He told in what way the old tuberculin had disappointed, that repeated injections of it were followed by repeated improvements, but that these improvements had a limit, for an immunity was established against the tuberculin itself. This immunity may last several months. This immunity has no influence on the tubercle bacilli; it is, therefore, purely a toxin-immunity, not a bacterial one. The power to react was, unfortunately, often lost before a complete cure was established. A return of this power of reaction had to be awaited before the treatment could be continued. Where, however, sufficient patience and skill were exercised many cases might be cured, and he would still have felt that in the old tuberculin we had the best remedy for tuberculosis if it had not proved possible from tubercle cultures to make a pure bacterial-immunizing preparation. This, to be brief, he prepared as follows: The tubercle bacilli from young virulent cultures were desiccated in vacuo, ground to pieces in a mortar, taken up in distilled water and the mixture centrifugalized. There resulted an upper slightly opalescent fluid and a sticky sediment. The sediment was dried and put through the above process again. The resulting sediment

* Read before the New York Surgical Society, May 8, 1907.

was again treated in the same way, and so on until only incidental dirt remained as a sediment. The first supernatant nearly clear fluid he called Tuberculin O (oberste Schicht), or, for short, TO. This he found had properties very like those of the old tuberculin. The subsequent fluids resulting from the grinding and other manipulations of the successive sediments were mixed together and named Tuberculin R (Rests), or, for short, TR. It was so made that 1 c.c. contained 10 mg of solid substance. This solid consisted of pulverized tubercle bacilli minus certain elements which had been extracted and were contained in the TO. A peculiarity of TR which distinguished it from the old tuberculin and from TO was that its injection was to a far less degree followed by a temperature reaction. Koch regarded this as a distinct advantage possessed by TR over TO and old tuberculin. Koch began with injections of $^1/_{500}$ mg. of TR and gradually raised the dose to usually 20 mg. These figures refer to the solid substance in the TR. Secondary symptoms to cause anxiety, or any other encroachments on health which could be ascribed to the preparation, Koch said he saw in no case. Especially striking was the progressive straightening out and return to normal of the temperature curve. He said he did not venture to maintain that the method of beginning with minimal injections and gradually raising them to 20 mg. was the best way of using TR. He thought other methods of procedure, perhaps even combinations of TR with TO or with sera obtained with TO or TR might be found to be more effective. But further improvement in the matter of preparations made from tubercle cultures he did not think was to be looked for.

Another important communication from Koch appears in the same periodical under date of November 28, 1901. The subject of agglutination of the tubercle bacillus by sera of patients had come up. Koch made an exhaustive study of it. Before this there had been no means of measuring the degree of immunity attained. Koch came to the conclusion that the agglutination test gave this needed measure. In earlier immunizing attempts he had given to TR the preference over

TO because TR gave relatively weaker reactions than TO. But, guided by the agglutination test he now found it better to use the undivided culture mass, and, further, that the agglutinating power in man as well as in animals developed most surely and quickly when the reactions were not too feeble and when the doses were raised as rapidly as possible. He made a new tuberculin containing one part of pulverized tubercle bacilli in 100 parts each of water and glycerine. One c.c. thus represents 5 mg. He began with injections of 0.0025 mg. and rapidly increased the dose. He found that when agglutination had set in, or when that originally present had been increased, it was important to continue raising the dose; otherwise the agglutinating power would sink. He went as high as 20 mg. and in some cases 30 mg. That the development of agglutinating power is actually associated with the formation of protective substances he felt could be inferred, because from the moment that agglutination was established in his phthisis cases the condition of the patients was distinctly better. Some patients failed to develop agglutination, and in them of course the agglutination test could not be used to control the treatment. The preparation which Koch used for his injections is known as "New Tuberculin Koch (Bacilli Emulsion)." Both it and TR, which is now labelled "New Tuberculin Koch (TR)," are manufactured by the Farbwerke vorm. Meister Lucius and Brüning and are imported into this country by their agents, Victor Koechl and Co., 122 Hudson Street, New York.

Koch felt that the agglutination test gave him a measure of the degree of immunity which his tuberculin was producing. Wright believes he has discovered a better measure in the opsonic index. He infers from experiments that there are substances in the blood which act upon bacteria to make them easier victims for the phagocytic leukocytes. These substances he calls opsonins. There are apparently various opsonins for the various microörganisms. The proportion of opsonin in the blood Wright takes to be the measure, if not the reality, of the immunity. The relative amounts of opsonin in the blood of a healthy individual and in that of a patient are determined

by observing the phagocytic powers of leukocytes when in the presence of bacteria acted upon by the serum of the patient, and their phagocytic powers when the bacteria are acted upon by the serum of a healthy individual. The average number of bacteria found in a polynuclear leukocyte in the case of the patient's serum, divided by the average number found in the case of the healthy individual's serum, is the opsonic index of the patient. It is expressed in decimals for convenience of comparing various indices.

I have chiefly concerned myself with the tubercular index. In spite of reading the contributions of Wright, I have found this work difficult. Dr. Simon Flexner has saved me much preliminary stumbling by showing me the opsonic work which Dr. Edwin H. Shorer has been engaged in at the Rockefeller Institute. I am deeply indebted to Dr. Flexner and Dr. Shorer for introducing me to the practical details of opsonic technique.

As the communications of Wright are accessible to all, I shall not take your time to describe the mode of determining the tuberculo-opsonic index in all its many details, but shall confine myself to speaking of the snags which I have encountered and the ways in which I have put them aside. The three ingredients for determining the phagocytosis are the serum, the mixture containing the leukocytes, and the suspension of tubercle bacilli. There is no trouble about getting the serum. The only point about the leukocytes is to centrifugalize them at such a slow rate that they shall not be pressed together into coherent clusters, but shall remain discrete. I find that if the centrifuge runs at 900 revolutions for half an hour the result is perfect. There is more trouble about the suspension of tubercle bacilli. For making this I have used the coarse powder of agglomerated bacilli which is a by-product in the manufacture of tuberculin. The method of grinding this in a mortar results in a considerable fragmentation of bacilli, which adds somewhat to the difficulty of counting accurately, and the grinding is tedious. I have discarded the mortar and have made a shaking machine which I use instead. It contains a mill-wheel run by water from an ordinary faucet. To the wheel-shaft is

attached a crank, and to the crank a rod, the further end of which plays through a bearing about 14 inches distant. To this rod is attached a trough, into which the object to be shaken is snugly packed in cotton and firmly tied. The stroke is 2 inches and the crank makes about 400 revolutions a minute. I put some of the bacilli powder, some glass beads and the suspension fluid into a glass tube and seal the tube. I put this tube in the shaker, turn on the water and let the machine run six or eight hours. Individual bacilli become disengaged in abundance and there are few fragments. I then fill a tube for two inches with the opaque shaken mixture and centrifugalize it at about 3,000 revolutions for six minutes, after which the top half inch is aspirated off. This fluid may contain too many bacilli, in which case the proper dilution is made.

Another difficulty I have found in getting the smears well stained for counting purposes. There are three desiderata. The bacilli should be intensely stained, so as to be seen with the least effort. The nuclei should be lightly stained, so that bacilli overlying them are readily seen. The outlines of the leukocytes should be visible.

I have struggled much over this matter and have arrived at the following staining method: Fix 20 seconds in wood alcohol. Wash. Stain 5 to 10 minutes in a bath of carbol-fuchsin, standing in boiling water. (I have made the carbol-fuchsin of double strength, 20 parts sat. alc. sol. fuchsin to 80 parts 5 per cent. carbolic acid, and evaporated it down on a water bath until it was of sufficient strength to make a good reddening of the smear in 5 minutes.) Wash. Decolorize one minute in 5 per cent. H_2SO_4. Wash. Counterstain 30 seconds in ¼ per cent. sat. alc. sol. methylene blue in ½ per cent. sol. Na_2CO_3. Wash lightly. Dry by agitation in the air. If the smears are good, the pictures are also good.

I wish I felt justified in saying something about results of treating cases of surgical tuberculosis under control of the opsonic index. I have encountered so many difficulties in the technique that my energies have thus far been mostly absorbed in trying to overcome these. In this field it is folly to make

clinical deductions until one is sure of getting indices of fairly uniform accuracy. As the sera of patients are supposed to vary widely without treatment and to fluctuate under the influence of treatment, the accuracy of the determination can best be gauged, it seems to me, by including in each batch of sera to be opsonized, the sera from more than one normal individual. These normal sera serve as opsonic standards in the same way that a pasted serum does, and in addition they serve as mutual controls upon the accuracy of the work. If the indices of the normal sera are not in accord, suspicion is cast upon the results in the whole series. I have adopted this method of control, using my own serum and those of my two sons. My results are as yet too few to warrant definite conclusions as to the accuracy of the technique or the value of the tubercular index, but my experience makes me feel that the results obtained by anyone who has not thus controlled his work until quite sure of his ground are to be received with scepticism.

Wright has used for his injections Koch's TR, and has generally begun with a dose of $^1/_{1000}$ mg. He has usually found that the index could be kept highest by using very small doses, rarely going higher than twice or three times this amount. In the matter of dosage he is thus at great variance with the conclusions reached by Koch when he controlled the dosage by the agglutination test. It would seem that if the opsonic index is the true criterion of dose and interval, then the agglutination test is not the true criterion. It is a question whether the Bacilli Emulsion is or is not better than TR in this treatment. The whole subject calls for much careful work with the closest coöperation between the clinic and the laboratory.

The brilliant results recorded by Wright and his colleagues compel enthusiastic attention to the subject, intricate and laborious though its demands are. Only through careful work by many impartial observers can its practical usefulness be shown. If others can achieve the results which Wright and his fellow-workers record we shall be able to treat effectively cases of surgical tuberculosis in which operative treatment and other surgical measures now leave so very much to be desired.

TUMOR OF THE CAUDA EQUINA REMOVED BY OPERATION: RECOVERY.

BY R. C. ELSWORTH, M.D., M.C., F.R.C.S., ENG.,

OF SWANSEA, ENG.,

Surgeon to the Swansea General Hospital.

TUMORS within the spinal canal are of sufficient rarity to justify the publication of the present case. It presented to the surgeon some points of interest and some difficulties in the matter of diagnosis and to the patient the not unimportant one of complete recovery.

Mrs. W., æt. 45, a widow. Personal and family history good. Complained of pain (sciatica, she called it) in both legs, lasting for at least four years. The pain began in the right leg about the middle of the back of the thigh, and "the painful area could at first be covered with the thumb." The pain was constant and of a gnawing character. She could not bear to sit squarely on a chair, owing to the pain, and had to sit on the edge so as to prevent the chair from pressing on the back of the thigh. Although the pain was constant it varied in intensity, was always worse after exertion, and frequently at night was so severe as to preclude all possibility of sleep. During the last two years the pain has become so severe as to almost completely incapacitate her from carrying on her ordinary household duties. During this time the only position of comparative comfort was lying curled up in bed. When she stood upright the pain rapidly became so severe that she was unable to remain erect, but on lying down again the pain would gradually diminish to its usual degree of intensity.

During these years the patient underwent various forms of treatment and consulted many medical men, her case being looked upon and diagnosed differently by each one who saw her. She was treated in a London hospital as a case of sciatica and had the sciatic nerves dry-stretched; she also underwent a course of electrical treatment, both galvanic and faradic, and, at a later date, in another hospital, a course of treatment with the high-

frequency currents. She was sounded for stone and had the cautery applied to the backs of the thighs. At a later date she was treated with rest and splints in a modified Weir-Mitchell treatment.

Although the pain began in the right leg, it was when I first saw the patient worse in the left leg.

Physical examination.—The first thing which struck one on looking at the patient was the wasting of the muscles of the buttocks and of the lower limbs. The gluteus maximus on both sides was wasted, soft, and flabby; so that the normal contour of the buttocks was lost. The hamstrings and ischial portion of the adductor magnus were wasted and flabby. The calf-muscles were so reduced in size that all appearance of calf was lost and the anterior tibial muscles were atrophied. The quadriceps extensors, though reduced in size, had not lost their contour and the adductors were not obviously affected.

The knees could not be straightened and the patient could not stand without support. There was no obvious wasting of the quadriceps extensor in either leg nor of the adductors. Although there was weakness of the wasted muscles, there was no paralysis. The knee-jerks were not altered; there was no clonus, and the plantar reflex was diminished.

The measurements of the two limbs showed that they were much smaller than would be expected in a person of that build, and the left was three-quarters of an inch less than the right all the way down. There were no tender points to be made out and the tactile and pain sensations were relatively diminished as compared with the front of the thighs, as also was the sensation of heat and cold. The skin showed no obvious change and there was no zone of hyperæsthesia either in the trunk or limbs.

There was pain on deep percussion over the lower lumbar region and pain was felt in the same place when the patient stood for a few minutes or bent forwards. There was no deformity of the spine and no evidence of sacro-iliac disease. The bowels were constipated and she did not pass water oftener than once in the twenty-four hours.

The salient points of the case were: 1. Pain in the back and along the course of the sciatic nerves. 2. Wasting of the glutei maximi muscles and all the muscles supplied by the great sciatic nerves. 3. Pain on deep percussion, on bending forward

and on standing in the erect position, the pain being felt in the lower lumbar region and radiating along the course of the sciatic nerves. The pain was constant and had been existant for at least four years, and the atrophy of muscles had been observed for at least two years.

Differential diagnosis.

Sciatica was negatived by both sides being affected and by the disease not being limited to the sciatic nerves; for the condition of the gluteus maximus clearly showed that the inferior gluteal nerve, at least, was involved and sciatica could not account for the pain in the back.

Neuritis was negatived by the extent of the lesion, its duration, the absence of paralysis and the causes which produce that disease.

Pressure on nerves from disease of the sacro-iliac joints was negatived by the extent of the lesions, its bilateral condition. It was impossible to conceive disease of both joints about the same age producing pressure in almost exactly the same place and to almost exactly the same degree; besides, there was no evidence of disease of the sacro-iliac joints or any other disease in the pelvis.

Finally we are brought down to the spinal canal. Pressure in the spinal canal could produce all the symptoms, and that, too, with a comparatively small lesion. If we look at the condition of the patient for a moment it will be obvious that the lesion from which she suffered was one that involved the fifth lumbar nerve and all the nerves below that level on both sides of the body. That the fifth lumbar nerve was involved was proved by the condition of the gluteus maximus, which it will be remembered is supplied by the inferior gluteal nerve derived from the fifth lumbar and first and second sacral nerves, and that all the nerves below that point were involved was proved by all the muscles supplied by the great sciatic nerve being wasted and by the retention of urine.

Pain was the first symptom and was constant throughout the disease; later wasting and muscular weakness supervened. A lesion in the spinal canal would account for all the symptoms, and such a lesion might be due to: a. Disease of the spine-caries, or b. Tumor in the canal.

The lesion in this case, because of the symptoms and progress, must obviously be situated on the posterior aspect of the

canal; so as to produce pain first and weakness and wasting later. And as caries of the spine practically always attacks the bodies and not the laminæ, and as there was no evidence of disease of the spine, the spine was excluded. The question of an exostosis on a lamina was put out of account because it seemed impossible that pressure by a hard rigid body could have existed so long and not have produced paralysis. The lesion, it was felt, must be soft because of the absence of paralysis.

Finally the question to decide was, is this a lesion of the cord or of the cauda equina?

A tumor, pressing on the posterior aspect of the spinal cord, must have destroyed the posterior region of the cord before it could have produced weakness and wasting. Moreover the tumor must have been a long one to catch all the roots from the fifth lumbar downwards and this would have meant the abolition of the reflexes and loss of sensation. If, on the other hand, the tumor had not extended over the whole region of these roots, but had been situated over the fifth lumbar segment, then the reflexes below that segment would have been increased by the lower centres being cut off from those above. For these reasons the cord was excluded and finally we come to the cauda equina.

Pressure at the level of the fifth lumbar vertebra would catch the fifth lumbar roots and all the roots below that point. It would catch the posterior roots first and then through them the anterior roots.

Finally we arrive at the diagnosis that the patient is suffering from a tumor in the spinal canal at the level of the fifth lumbar vertebra, that it is soft and probably non-malignant.

Operation January 12, 1907. The spinal canal was opened in the usual manner and the dura mater exposed, and a zone of thickened and congested dura brought to view at the level of the upper border of the fifth lumbar vertebra. On opening the theca an encapsulated tumor was found extending along the body of the fifth lumbar vertebra and into the upper part of the sacral canal for the matter of half an inch. The growth was easily shelled out without injury to the nerve roots. These were all found to be pressed forward against the vertebral body except one, which was pressed against the postero-lateral wall of the subdural space on the left side. After removal of the tumor the edges of the theca were drawn together with a continuous suture

and the rest of the wound closed in the usual manner, deep sutures being used to approximate the muscles and close in the space. The wound healed by first intention and the after-treatment presented no special features of interest. A catheter was passed three times daily after the operation for the first ten days, so as to avoid any possibility of the dressings becoming soiled and the wound thereby infected. After that time it is interesting to note that the patient voided urine naturally and the usual number of times in the twenty-four hours; in fact, that the retention which she had had so long ceased.

For some weeks the patient complained of pain in the old positions, but notwithstanding this she slept well and her limbs began to grow. Seen May 25, 1907, she expressed herself as quite well; she is able to walk two miles without a rest; attends to her ordinary household duties and her garden, in which she is much interested. She has gained considerably in weight, and the limbs have grown till they present quite normal proportions. The actual measurements of the two limbs before and after the operation are as stated below:

BEFORE OPERATION

	Right	Left
Thigh	16⅞″	16⅜″
Calf	12¾″	11⅞″

AFTER OPERATION, May 25th, 1907

	Right	Left
Thigh	21¼″	21¼″
Calf	14⅜″	13¾″

The pathological report stated that the tumor was fibro-muscular, with large vessels, but no trace of malignancy.

MULTIPLE EXOSTOSES, INCLUDING AN EXOSTOSIS WITHIN THE SPINAL CANAL WITH SURGICAL AND NEUROLOGICAL OBSERVATIONS.

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AND

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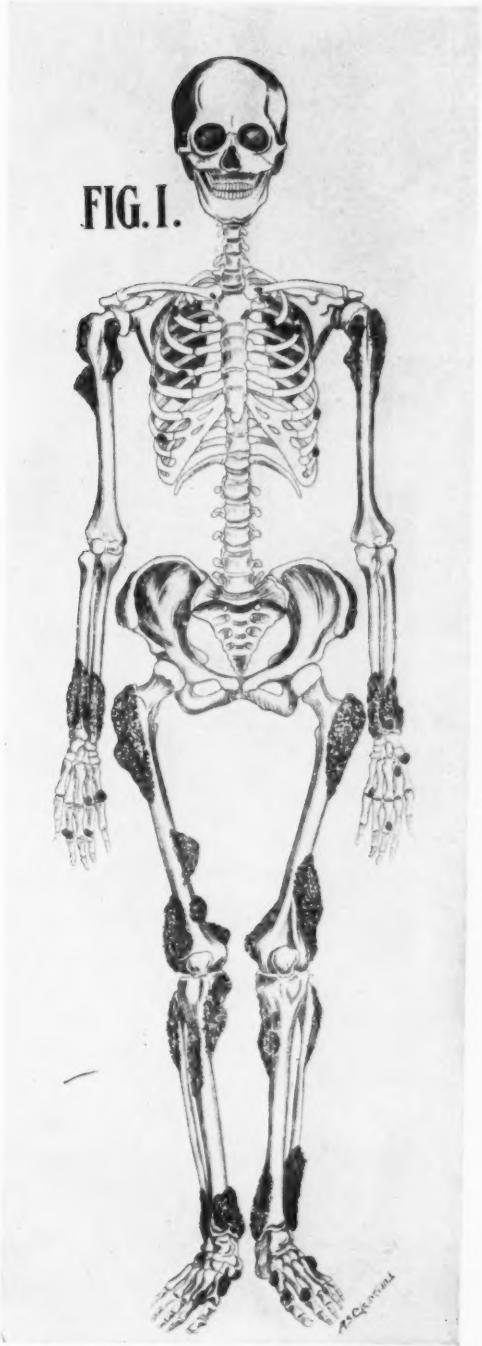
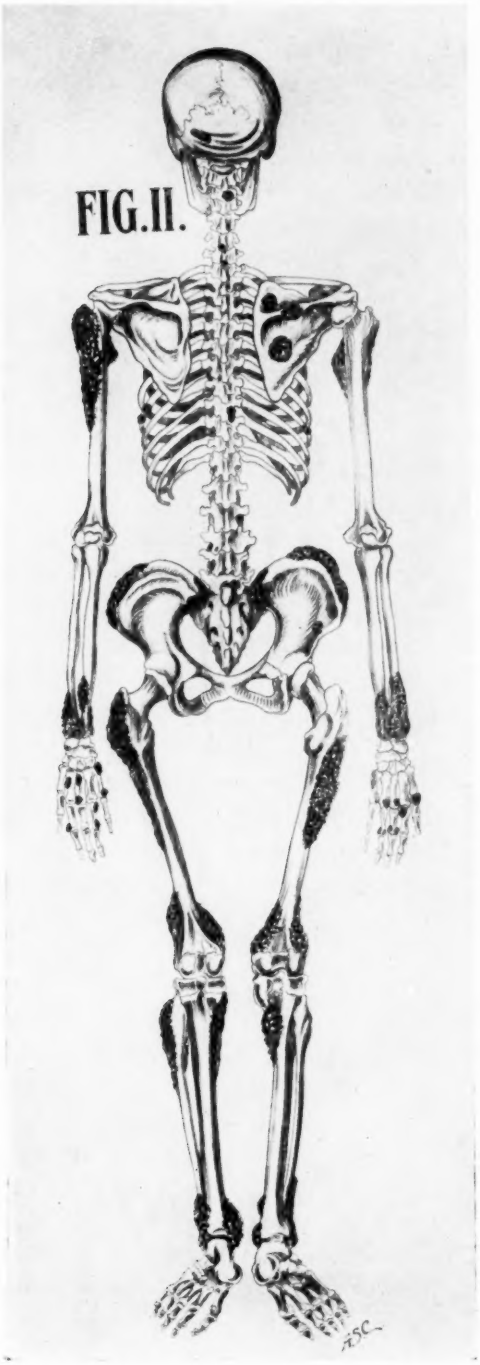
Exostoses of the human skeleton occur as chondroma, osteochondroma, and osteoma. They are not very common and fortunately those cases in which the exostoses cause marked disturbances are very rare. In the following case one of the exostoses caused serious trouble.

The patient, male, age twenty-three, was admitted to the Augustana Hospital October 8, 1906. No history of similar trouble among any of his relatives for several generations back. Father died at the age of forty with meningitis, probably tubercular, after an illness of several weeks. His father's left hand had been injured in a saw-mill several years before his death, causing ankylosis of all of the fingers of the left hand, the index and middle finger being held straight, the ring and little finger slightly flexed. There were also numerous bony irregularities on these fingers. During his last illness, while the mother was several months pregnant with the patient, the mother repeatedly stroked this irregular hand. Patient and patient's mother ascribe his exostoses to this prenatal influence, more especially as the patient habitually held his left hand in this same position during the first few years of his life, though the joints were never ankylosed. Except for these multiple exostoses patient has always been well.

At the age of fourteen first occasionally noticed slight incoördination of the lower extremities. When trying to move quickly and especially if tired, lower extremities would tremble



Anterior view of skeleton with multiple exostoses.



Posterior view of skeleton with multiple exostoses.

and he could not place the feet exactly where he wished them to go. This became appreciably worse, especially in the right leg, and later appeared in the right arm. Since February, 1906, his right leg has dragged more than usual, his right hip seemed more stiff, and he had greater difficulty in walking. Since August, 1906, he has noticed that he has had less accurate control of his right arm and hand and that the tactile sense of his left arm and hand was somewhat impaired. From this time on the condition grew progressively worse, though there were intervals of slight remission, lasting sometimes for only a few hours at a time, so that by November 27, 1906, the patient was unable to walk at all even with crutches.

March, 1906, while pitching hay and straining considerably he had a feeling as of wrenching his neck, which caused pain on the right side of the body lasting about two hours. One month later he suddenly turned his head to the right and had a similar pain, plus a pricking sensation in the back and right side of body. After this every time he turned his head suddenly to the right this same pain would recur. Turning to the left caused no trouble. Since May, 1906, he never turned his head to the right; instead, when wishing to turn to the right, he would rotate the whole body. June, 1906, patient injured right knee, causing as he thinks a laceration of the ligaments.

On careful examination we found one-hundred-and-eight exotoses, as represented in Figs. 1 and 2. It is to be observed that there is one on the left superior curved line of the occipital bone. This is very unusual. In a rather careful study of the literature we were unable to find any reported case of an exostosis springing from the external surface of the bones of the roof of the cranium. It is supposed that the bones of the roof of the cranium are developed in membrane, hence are epiblastic in origin, while nearly all the remaining skeletal bones are developed from cartilage and are mesoblastic in origin. It has occurred to me that possibly there is this developmental reason for the fact that exostoses do not as a rule spring from the roof of the cranium, while they are found attached to practically any one of the other bones and it may be that in this case the tabular portion of the occipital bone

developed from cartilage instead of developing in membrane and that this might account for the exostosis which we find here springing from the superior curved line of the occipital bone.

A very common location for exostoses is the ventral surface of the scapulæ, and in this case too we find a large exostosis on the ventral surface of the right scapula. The epiphyseal lines of the long bones and the insertion of tendons are also favorite seats for their development and in these two points our case conforms to the general rule. Their location and attachment to the various bones, as well as the density of the tumors is very clearly brought out by the skiagrams kindly furnished me by Dr. Reichmann, as represented by Figs. 3 & 4.

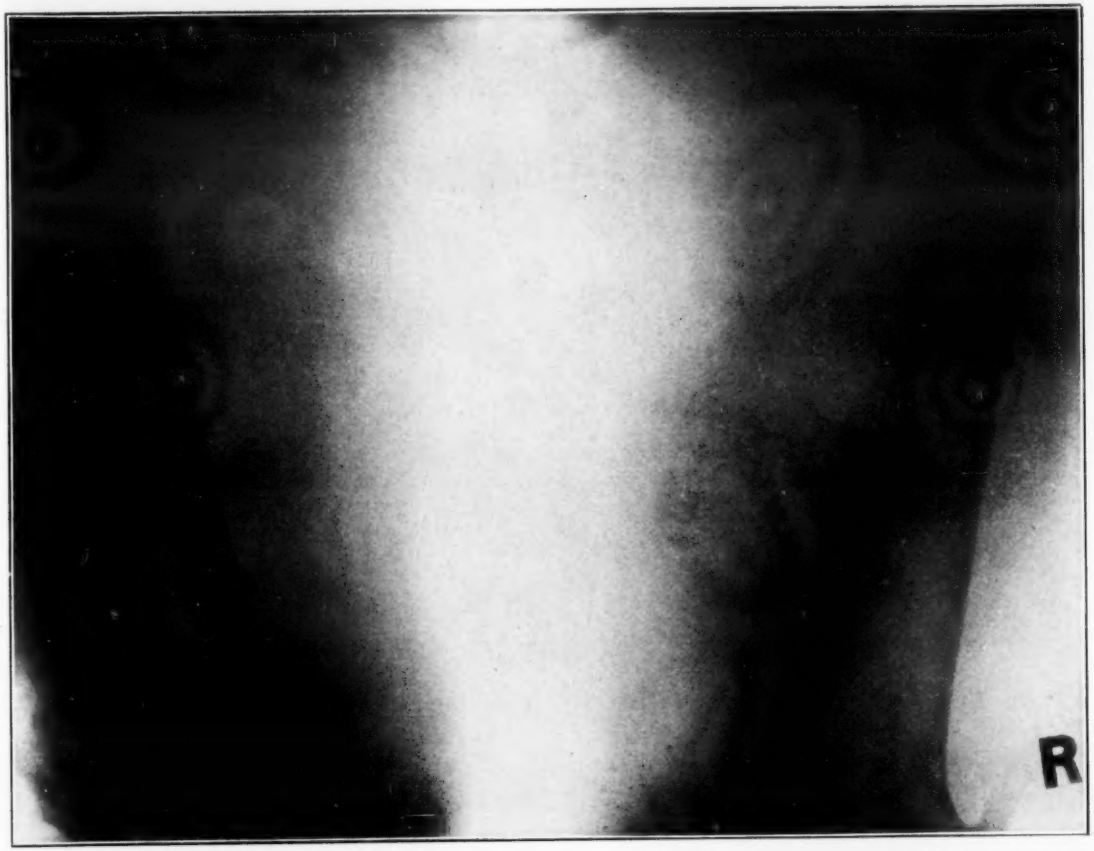
The question as to the age of development of these exostoses is still unsettled. In this patient the exostoses were first noticed at the age of two, and the patient thinks they continued to grow at about the same rate as the body and stopped growing with the body at the age of nineteen. This also is very doubtful, however, because it was not until after he was nincteen that the cord symptoms became at all pronounced, and my assistant, Dr. Abelmann, who has observed this patient very carefully for the last four months is of the opinion that several of the exostoses, especially the one under the right scapula, have increased in size since the first examination. By some writers it is also claimed that these exostoses will occasionally spontaneously disappear in later life. In this case we have no evidence that any have either decreased or have disappeared.

With the above history the question naturally arose as to how much of the disability was due to the rather severe injury to the right knee which the patient had sustained in June, 1906; whether or not there was some central nerve lesion, and if a central nerve lesion, was it an undiscovered exostosis making pressure upon the central nervous system, or was it a disease of the central nervous system itself. For solution of this question the patient was referred to the neurologist, Dr. Rothstein, whose findings of the nervous symptoms follow below, and who was

FIG. 3.

Skiagram of bones at shoulders affected by exostoses.

FIG. 4.



Skiagram showing femora.

able to make a rather definite diagnosis as to the location of the trouble. He referred the disturbance to the right half of the cord between the base of the skull and the upper border of the fifth cervical vertebra, probably opposite the second.

The patient was consequently anæsthetized and the incision made in the median line extending from the external occipital protuberance to the sixth cervical vertebra, muscles and fascia separated from the vertebra, spinous processes and laminæ of the second and third cervical vertebræ removed with bone forceps and attached by a small pedicle to the anterior surface of the right half of the second cervical vertebra. The tumor, represented by Fig. 5, was found within the dura pressing upon the cord and flattening it out considerably. The tumor proper was attached by the small pedicle to the lamina of the vertebra, the pedicle passing through a small hole of the dura, the tumor itself lying within the dura directly on the cord. When the tumor had been removed the cord appeared normal and bulged out. Fig. 5 represents the condition found as accurately as could be determined. The left lamina seemed to be more vertical than normal and shorter, while the right was longer than normal; the spinous process was consequently deflected a little to the left of the median line. Fig. 6 shows an average second cervical vertebra of normal size, while Fig. 5 represents a drawing based upon the normal in size, but modified in shape according to the conditions observed with the tumor drawn in its actual size.

It seems almost incredible that the cord could have sustained so much pressure for so long a time and not have suffered more. The dura had to be incised in order to get the tumor out, and no attempt was made to suture it. A small gutta percha drain was introduced down to the cord, the wound closed, and a large antiseptic dressing applied.

All of the operating on the vertebræ was done with the greatest care, and the tumor removed as gently as possible, and yet, on regaining consciousness, the patient complained of numbness of the whole body and was unable to move any of his extremities, anal sphincters were completely relaxed, the bladder was paralyzed. Five hours after leaving operating table slight motion in left arm and leg, but none in right; sphincters still relaxed, bladder still paralyzed. Eighteen hours after leaving operating table complete loss of sensation of left upper extremity,

impairment of sensation in remaining extremities, motion of left arm and leg fair, except that left arm was ataxic, muscle sense being completely lost, right arm and leg, right half of diaphragm and right intercostal muscles completely paralyzed. About two weeks after operation, motion began to return on the right half of the body, and since this time sensation and motion have slowly but gradually improved, and now three months after the operation he is greatly improved. He is now able to move his neck in every direction without the slightest pain and he is able to walk very comfortably with crutches, though he still suffers considerably from ataxia. His exact status is also given below by Dr. Rothstein.

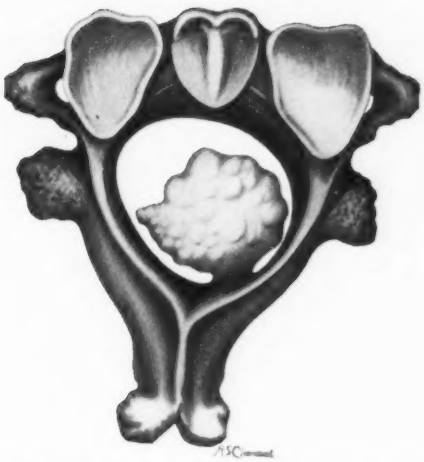
It is only occasionally that operative intervention is required in cases suffering from multiple exostoses, because fortunately these tumors are usually located where they do not cause any great harm or inconvenience. Some of the indications for operation are excessive weight of the tumors, or their location in places where they cause pressure sores, interference in the mobility of joints, pressure upon nerve trunks with their resultant neuralgias and pressure upon important organs as in the case above given in detail.

Some years ago I saw a case in which it was necessary to remove an exostosis from the upper end of the radius because it caused interference with the rotary motion of the forearm. Recently I have had to remove a multiple exostosis of the lower end of the radius for the same reason. These three cases are the only cases of exostosis that I have ever seen where operative interference seemed indicated.

NEUROLOGICAL OBSERVATIONS.

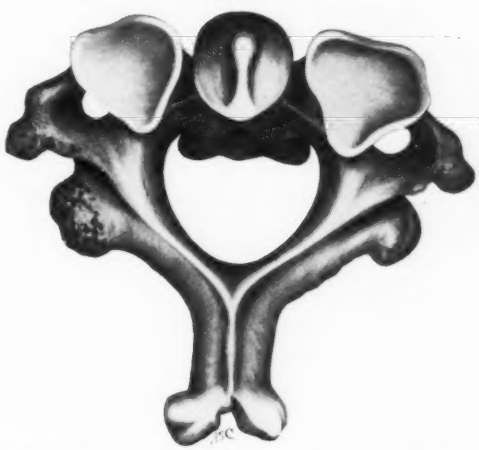
When I first saw the patient he presented the picture of a spastic paresis, more marked on the right than on the left side. He was able to walk but little on account of the stiffness in his legs. After a few steps his legs, especially the right one, would come into a state of trembling, making it impossible for him to walk. The trembling once started would persist for some time, but would gradually subside during rest. Active movements

FIG. 5.



Exostoses springing from one of the lamina of axis and growing into the spinal canal.

FIG. 6.



Normal axis, to compare with diseased axis shown in fig. 5.

would cause trembling also in the arms, intense in the right arm, slight in the left. His right arm was contractured, being held in adduction and flexed to right angle in the elbow joint, and the hand was halfway closed. He was able to execute actively only very slight movements in the shoulder joint, and in the elbow joint flexion and extension of about ten degrees. The fingers could only be slightly extended and flexed, the hand being completely useless. With the right leg he could execute active movements more freely, but all the movements were weak and much limited in comparison to the normal.

Passive movements in any joint of upper or lower right extremity would meet with intense resistance. The left arm and left leg were weak, but could be freely moved actively. Passive movements would meet with some resistance.

The tendon reflexes of all four extremities were increased. Wrist and patellar clonus existing on right side, foot clonus on both sides, a strong Babinsky reflex on right and a slight but distinct Babinsky reflex on the left side.

The cutaneous reflexes were lively.

The only disturbances of the sensibility possible to demonstrate were a slight ataxia in left arm and leg and inability to recognize objects with his left hand when his eyes were closed.

His tongue was slightly asymmetrical, the left half being somewhat smaller than the right, and when the tongue was protruded it would sometimes deviate to the left.

The fundi of the eyes were normal, but a distinct nystagmus could be observed when the eyes were moved to the extreme left or right.

He had perfect control of the sphincters.

The above described symptoms might suggest the diagnosis of a disseminated sclerosis, or some other kind of sclerotic process in the central nervous system.

The patient presented, however, a symptom which directly pointed to the existence of an exostosis in the spinal canal. As Dr. Ochsner already has mentioned, the patient sometimes felt a sharp pain shooting through his whole body when he turned his head to the right. This pain occurred only when he turned his head suddenly to the extreme right. Sometimes it happened that at the same time as the pain was felt in his whole right side from the neck down to the toe, he also felt a pain shooting upward in

the back of his head on the right side. When he, immediately after such an intentionally produced pain, outlined the course of the pain in the back of the head, it was found that the pain followed the course of nervus occipitalis minor on the right side. As nervus occipitalis minor gets its fibres from the second and third cervical root (that is, the nerves which leave the spinal canal, the one immediately above and the other immediately below the second cervical vertebra), the mentioned symptom pointed towards the second cervical vertebra as being the seat of the tumor. By examination of the shoulder muscles it was found that the musculi rhomboidei and musculi levator anguli scapulæ on the right side were much weaker than the corresponding muscles on the left side, and percussion of the trigonum scapulæ would cause much more lively contractions in rhomboidei and levator anguli scapulæ on the right side than on the left. As the new fibres which supply musculi levator scapulæ do not leave the spinal cord lower down than the fifth segments (corresponding to the level of fourth cervical vertebra), it was clear that if the spastic process was due to anosteomia this must sit on the fourth cervical vertebra or higher up.

On account of the mentioned pain along the nervus occipitalis minor it was, however, considered that the supposed tumor most likely would be found on the second cervical vertebra. The motor symptoms being so much more pronounced on the right side, it was necessary to assume that the tumor pressed upon the right side of the cord, but there one would expect some of the symptoms usually present in a halfsided lesion of the cord. A slight suggestion of such a lesion gave the ataxia of the left extremities and the sensory disturbances of the left hand. The nystagmus and asymmetry of the tongue might be explained either as congenital or as symptoms of intrinsic affection of central nervous system.

A week after the operation the patient presented a typical picture of halfsided lesion of the cord, with loss of all the different qualities of sensation, including muscle-sense, on the left side, with hyperæsthesia and flaccid motor paralysis on the right side. He gradually improved, and three months after the operation his condition was the following: Active motility of left upper and lower extremity normal; no stiffness on passive movements. Right arm can be adducted from the body and lifted up to 135°,

and rotation is nearly normal. Full flexion and extension are possible in the elbow joint, but by extreme extension motion becomes a little slow.

Pronation and supination are of less than normal degree. Flexion and extension of right wrist joint 40°. The thumb can only be slightly extended and flexed. The right index finger can be fully extended and flexed, but the other three fingers cannot be extended fully, especially not the little finger. He can spread and adduct the fingers to some degree. The grip of the right hand is weak, but has increased considerably in strength. By passive movements some resistance is felt, but the stiffness is easily overcome.

The passive and active movements in the ankle and toes are nearly normal, some resistance existing in the ankle joint by passive movements. The movements of left knee and hip joint could not be examined on account of a plaster cast having been put on the leg.

The patella-reflex on left side somewhat decreased. On left side no ankle clonus is present and only a slight amount on right side. A slight Babinsky reflex can be elicited on left and also on right side.

The tendon reflexes of right arm seem about normal. The abdominal reflexes are more lively on left than on right side.

Sensation for touch-, temperature-, pain-, and muscle-sense were normal on right side. On the left side a slight stroke with cotton would not be felt over dorsal aspect of the two extreme phalanges of all the fingers, neither would it be felt over dorsal aspect of foot and toe. If the pressure of the cotton was made a little heavier, the touch would, however, be felt. The patient stated himself that although he felt the slight touches of cotton over the rest of the left side he did not feel the touch nearly as clearly on the left as on the right side.

Sensation for pain was decidedly decreased over the whole left side, with exception of the area supplied by nervous trigeminus.

All passive movements in any joint on left side he would perceive and judge nearly correctly, but by active movements a marked ataxia was apparent in the hand. An object, knife, coin, etc., put in his left hand (when his eyes were closed) would not be identified and invariably dropped.

Sensation for temperature was decidedly diminished on the left side.

The nystagmus seems to be less marked than before the operation.

The patient returned to the hospital and was examined again May 30, 1907.

He is considerably improved. He is able to use his right hand to some extent, to dress himself and button his clothes, which was impossible for him in the month of March. He walks now without crutches, but his right arm is carried somewhat stiffly, usually flexed in the elbow joint. The right leg is still in a cast. The right arm can now be stretched straight upward, and can be fully extended and flexed in the elbow joint, although the last part of the extension is still a little slow.

Flexion and extension in wrist joint to 45° and 50°. Fingers can be fully extended and flexed except thumb and little finger. Grip of right hand has gained considerable in strength, but is still much weaker than grip of the left hand.

Passive movements in all joints of right extremities meet with some resistance, especially if the movements are done suddenly.

Marked Babinsky reflex. Foot and patellar clonus exist on right side.

The tendon reflexes of right arm increased.

On the left side stroking of the foot sole causes flexion of the big toe and the patellar reflex is lively. Abdominal and cremaster reflex much livelier on left than right side. Feels slight stroke of cotton over whole left side, but sensation a little uncertain over dorsal aspect of the foot and toes. Sensation for pain has improved, but needle is still felt less sharp on left than on right side. His ataxia is also considerably less than in the month of March. Objects put in his left hand are usually not recognized, but they are felt and not dropped.

The reflexes which after the operation became decreased have later gradually increased, such as the left patellar reflex, the foot clonus on the right and the tendon reflexes of the right arm. But the Babinsky reflex on left foot disappeared, and the sensibility and mobility have in the same time improved.

The nystagmus is markedly less than before the operation.

TUBERCULOSIS OF THE ELBOW, ARTHROPLASTY.

BY GUALTIERO DE AMEZAGA, M.D.,

OF BOSTON, MASS.

THE following is a brief account of a successful attempt to reëstablish a hinge joint at the elbow, after resection of the joint for tuberculosis. The result is the more interesting since the case has been followed for three years after operation:

History, R. P., 18 yrs.—She was first seen at the Massachusetts General Hospital in 1903, where she was successfully operated upon for tubercular glands of the neck. There has been no recurrence after four years.

In the following year, March 18, 1904, she again appeared at the Massachusetts General Hospital with a history of pain in the right elbow. The following notes were made at that time:

"About one month ago R. P. began to have pain in the right elbow, when she used that arm, and this pain has continued ever since. An attempt to straighten the elbow is unsuccessful, and causes great pain. Heat and swelling have been present during the period when the pain has been noted. The pain is worse at night, and is relieved somewhat by elevating the elbow on the pillow. X-ray examination and internal angular splint advised.

The day after the first examination the patient returned and was re-examined with the X-ray plate for comparison. The elbow gave signs of fluctuation, and the X-ray plate showed foci in the ulna, with a certain amount of disintegration of the joint. Operation was advised but refused."

The girl went about to the various out-patient clinics of the city, where she was advised to have an operation. She came to me in June, 1904. I advised, and performed immediately resection of the elbow joint.

Examination.—At the time of the operation the elbow was large, swollen and tender. On either side of the olecranon process and the biceps tendon a bulging mass presented which gave signs of fluctuation. A short time before I first saw it, the joint had been punctured on its inner aspect, from which a

mixed infection had resulted, marked by a temperature elevation to 104°, increased tenderness, and constitutional symptoms. *The motions* of the joint, at this time, were limited. The forearm was habitually extended to about 120°, though it could be flexed to 80°, an angular excursion of some 40°. This motion was obtained with great difficulty, and at the expense of eliciting severe pain in and around the joint. As to pronation and supination, the wrist could be twisted from a position of 90° pronation to 45° supination; in other words, rotatory motion at the elbow joint was much limited. The bulging synovial cavity, with the surrounding infiltrated structures, constituted a tumor about four inches in diameter, antero-posteriorly, and about four and one-half inches measured in a lateral plane. The physical signs, therefore, showed advanced disease of the elbow joint with distension of the joint capsule, spasm of the adjacent muscles, and infiltration of the soft parts in relation.

A series of operations was done in this case. The patient was etherized on eight occasions, on all but three of which the procedure was in the nature of an ether dressing: to break up adhesions, or to curette a cavity.

First Operation, June, 1904.—Incisions: These were three and, together formed an H-shaped figure placed in the following manner:

(1) A five-inch incision was made over the olecranon, parallel with the long axis of the bone. This passed through the triceps tendon and muscle down to the capsule.

(2) A second four-inch incision was made parallel with the first over the internal condyle.

(3) A cross-cut connected the two previously made incisions. This was made with the greatest care to avoid wounding the ulnar nerve.

The joint was opened and found to be disintegrated and filled with grumous, infected material. The flaps were reflected, and the disease followed upwards and downwards into the arm and the forearm. The forearm muscles were separated from their attachments to the condyles of the humerus, and subperiosteal resection done four inches above the condyles. The periosteum was left intact nearly to the joint.

The upper halves of the ulna and the radius were riddled with disease, and by curettage and excision the mischief was

cleaned out. The removal of the foci and their extensions required the resection of the head of the *radius* close to the bicipital attachment. Behind this a shell of periosteum remained, as the interior of the bone was scraped away for nearly its upper half. In the *ulna,* complete section was done just behind the coronoid process. From this point a narrow spicule of bone reached back for two inches, until it lost itself in the periosteal cavity which was the relic of the upper half of the ulna, after scraping away the disease. The bony bit left behind at the upper extremity of the ulna overlapped, by two and one-half inches, the point reached by the periosteal remnant of the radius. As will be seen later, the subsequent development of this bony ulnar extremity proved of marked mechanical value in the construction of a tightly-fitting joint. The interosseous nerve was identified during the dissection and preserved. The longitudinal cuts were approximated with interrupted sutures, since the tissues were too infected to allow suture by layers. The cross-cut was left open, and the gap, thus provided, was utilized for drainage purposes. The joint drained for eight weeks and various materials were employed to keep it open while the periosteal cavities were filling; silk-worm gut strands arranged in fagots proved very satisfactory.

The extremity was put up in extension and held there for two weeks. During this time the periosteal sacs had become slightly stiffened, and a move was made to effect more complete isolation of the bones above and below the operative site.

Second Operation, Two Weeks After First.—The patient was etherized and gauze packing insinuated between the upper and the lower arms, thus filling the granulating cavity left at the field of the previous operation. The extremity was again placed in extension, and thus retained for the two weeks following.

Third Operation, Four Weeks After First.—There seemed to be a distinct rigidity discernable in the region of the periosteal shells. The sponge packing was removed, and the bones of the lower arm lifted until their cut ends bore upon the shell of growing bone, which was now replacing the old, and forming the new lower articular surface of the humerus. The overlapping fragment of the ulna was passed by the humerus to the inner side, thus permitting the approach of the radius to and its articulation with the humerus.

The extremity was fixed in a position of acute flexion. In

this posture the bones were immobilized for two months by means of internal splints angular to various degrees of acuteness. Passive angular and rotary motions were undertaken two days after the third operation, the arm being restored to the splint after the exercise.

Ether was given subsequently five times, as alluded to earlier, sometimes with the intention of freeing adhesions, at others of loosening tags of detritus caught in the sinus.

End Results.—There is a *shortening* of four inches in the affected arm. An effort was made at the first operation to save part of the epiphyseal line on the ulna, but it is doubtful whether it was successful. If my measurements do not deceive me, during the past year the difference in length of the two arms has been reduced nearly one inch.

Motions: Rotatory is perfect. In pronation the projecting ulnar process hugs tightly the humerus, thus gaining a *point d'appui,* so that the spiral rotation of the radius over the ulna causes no lateral displacement or wobbling. Perfect supination is present.

Angular Motions.—Flexion—to 36 degrees; extension—to 150.5 degrees.

Motions of the Fingers.—These are perfect, strong extension and flexion, being both accomplished with freedom.

The Mechanism of the Joint.

Angular Motion.—As a whole, *during extension,* the ends of the forearm bones rest near the upper edge of the notch in the humerus. The ulna, at this time, is separated from the humerus for about one-quarter inch; the end of the radius remains attached to the ulna, but in front of the humerus. As the arm is flexed the radius and the ulna are pushed backwards and downwards; backwards until close articulation with the humerus occurs, whence it glides downwards for about a half inch along the curve of the socket, where it rests during the completion of flexion.

Rotary Motion.—In supination the radius lies in front of the humerus, slightly to the inner side, in close relation with the ulnar end. At this point the ulna forms a hook and articulates with the other two bones as follows: the lower half

of the hook supports the radius, and provides a fulcrum for the same, quite similar in principle to the relationship of these bones in a normal joint. The upper half of the hook bears upon the humerus. *When pronation occurs* the new radial head turns in its new bed, while the shaft twists over and to the inner side of the ulna. This twist pushes the ulnar hook outwards until it meets the humerus, when ulna and humerus lock firmly together, and here they remain, in close embrace, while complete pronation is effected.

Conclusion.—No general conclusions can be drawn from one case. It would seem, however, that a good mechanical

FIG. 1. Cross section. Extension. Supination.

FIG. 2. Cross section. Flexion. Supination.

FIG. 3. Cross section. ¶ 90° Flexion Pronation.

outcome should generally follow the employment of the technique described above, since this successful result was obtained in the face of unusual difficulties. The widespread tubercular involvment of the bones and the soft parts, the mixed infection, and the indolence of the reparative process, presented a discouraging picture. In cases of ankylosis in which the original infection had subsided, these primary obstacles to success would be minimized.

Many attempts have previously been made to obtain a fulcrum for the play of the arm bones. The introduction of soft parts between the bony articulating surfaces may prevent ankylosis, but it cramps the motions by omitting to provide for a socket.

The obvious disadvantages of a flail joint need no comment. The two factors which contributed chiefly to the restored elbow function of my case were: (1) the new socket in the humerus, (2) the firm grasp of the humerus by the hook of the ulna.

It is now three years after operation, and the girl is working in a factory eight hours a day, and often carries heavy weights up and down stairs with the operated arm. The gross and the X-ray photographs are explained by their legends.

FIG. IV.

Final result of arthroplasty of right elbow. Lateral view, extended to 150.5° 1907, 3 years after operation.

FIG. V.

Final result of arthroplasty, right elbow. Lateral view, flexed to 36°, 1907. Complete flexion.

FIG. VI.

Arthroplasty, right elbow. Lateral view, flexed to 41°, corresponds to Fig. V. Note relation of forearm bones to tip of humerus.

FIG. VII.

Arthroplasty, right elbow. Lateral view, extended to 150.5°, 1907, corresponds with Fig. IV. Note: separation of bones during extension, scattered bony deposits about joint, tip of ulnar process slightly overlaps humerus.

FIG. VIII.

Arthroplasty, right elbow. Antero-external-posterior view, extended to 150.5°, viewed from behind: 1907, corresponds with Fig. IV. This view is not exactly a front one, but is taken somewhat from the outside as well. This throws the shadow of the forearm bones to the inner side, but it brings out the hook of the humerus. Note hook of ulna, with its radial articulation, also end of radius. The irregularities are undoubtedly filled with soft parts.

OLD UNREDUCED POSTERIOR DISLOCATIONS OF THE SHOULDER.

BY JOHN G. SHELDON, M.D.,

OF KANSAS CITY, MO.

THE importance of the long tendon of the biceps, in preventing and maintaining reduction in certain cases of dislocation of the shoulder, has generally escaped attention. It seems probable that in posterior dislocations of the shoulder the long tendon of the biceps may be torn from its groove between the tuberosities of the humerus and, on account of its displaced position, not only interfere with the reduction of the dislocation, but may displace the head of the humerus after reduction has been accomplished.

CASE.—A posterior dislocation of the head of the humerus was reduced three times during the first month after the accident occurred. Reduction was accomplished at each attempt, but the dislocation promptly recurred. Examination eight months after the injury showed the biceps tendon displaced from its groove and passing directly from its origin over the centre of the glenoid fossa. No bloodless reduction was attempted at this time. The joint was exposed; reduction accomplished; the displaced tendon of the biceps put into place and retained between the tuberosities by means of a periosteal bridge, and the soft parts repaired as much as possible. At this time, one year after the operation was performed, the extremity is useful and painless.

Alexander W., a clerk thirty-eight years of age, was thrown from a bicycle during July, 1905, producing a posterior dislocation of the right shoulder. Reduction was accomplished without the use of general anæsthesia. Examination one week later showed that the dislocation had recurred. A surgeon was called in, who reduced the dislocation under general anæsthesia. Recurrence was prompt, and in two or three days reduction was again accomplished under general anæsthesia. It was said that the last reduction was difficult and prolonged. In a week the bones were

again found out of position, but no attempt was made to put them in place.

The extremity was painful and practically useless. During the next few months the pain increased in severity and the muscles became atrophic, although massage and passive motion were employed.

I saw the patient with Dr. A. N. White, of Denver, Colo., about eight months after the injury occurred. At this time the dislocation was easily made out, and it could be determined that the long tendon of the biceps no longer occupied its normal position in the groove between the tuberosities of the humerus, but passed from its origin directly over the glenoid fossa of the scapula. There was no sensory or motor paralysis.

Operation was performed March 12, 1906. The joint was exposed by a deltoid flap, dividing the deltoid near its insertion and turning the muscle upward. The head of the humerus was found in the subspinous fossa. The supraspinatus, infraspinatus and a portion of the teres minor were detached from the greater tuberosity. The long tendon had been torn from the bicipital groove and the transverse ligament had been destroyed. The capsule of the joint had been detached from the head of the humerus and was contracted into a cicatrical mass about the glenoid cavity. It was incised and pushed out of the way sufficiently to clear the glenoid fossa. Reduction was then attempted but could not be accomplished. It was found that the subscapularis, which had not been torn from its insertion, prevented reduction. This muscle was divided in sections close to the lesser tuberosity. The dislocation was now reduced. The biceps tendon was placed between the tuberosities and a flap of periosteum sutured over the tendon to hold it in place, making, as it were, a new transverse ligament. It was impossible to repair the joint capsule. Some of the cicatrical tissue, together with a portion of the fascia of the under surface of the deltoid, was sutured to the periosteum over the tuberosities to assist in maintaining reduction. The deltoid was united with catgut and the wound closed without drainage. The arm was held in abduction with a plaster dressing.

Ten days later the dressing was removed and the wound found to be healed throughout. The arm was gradually brought down to the side. Passive movements and massage were resorted

to and voluntary motion was encouraged during the third week following the operation. Two months later the patient had very good control of the extremity. Flexion and internal rotation were normal, but outward rotation was somewhat limited and abduction very slight. The strength and range of motion gradually increased so that six months after the operation was performed the extremity was sufficiently serviceable to accomplish ordinary work. One year after the operation the patient states that "the arm is as good as the other one." This statement must be modified. I recently examined the patient and found a very useful extremity indeed, but found abduction limited to the horizontal position. Further abduction is accomplished by an upward rotation of the scapula and not by movement at the shoulder joint. The deltoid is weak but does not seem atrophic. The remainder of the extremity is apparently normal. The shoulder and arm have not been painful at any time since the first week after the operation.

The reports of cases of old unreduced posterior dislocations of the shoulder are so few that it is impossible to draw definite conclusions regarding the indications for operative treatment, or the operative procedure that is best suited to these patients. It is generally agreed that operation should be done when bloodless methods fail to reduce the dislocation, and if operation is necessary, early operation is desirable. Not all surgeons deem it advisable to perform early operations in these cases. According to J. E. Mears [1] many operators, especially English surgeons, advise operating six to eight weeks after the dislocation has occurred. Souchon,[2] who in 1897 made an exhaustive study of old unreduced dislocations of the shoulder, states that, "It goes without saying that no operation should be attempted before all possible means of bloodless reduction have been conscientiously applied in recent as well as in old irreducible or unreduced dislocations." There may be exceptions to Souchon's statement, and it would seem, from the case herewith reported, and a consideration of the anatomy about the shoulder joint, that a displacement of the long tendon of the biceps, which may occur in backward

dislocations of the shoulder, is a condition that demands a violation of this very good rule. If in a posterior dislocation of the shoulder it can be determined that the long tendon of the biceps has been torn from the bicipital groove operation should be done at once. Even if reduction can be accomplished by manipulation the abnormal position of the tendon, passing over the shallow glenoid fossa, will, when the biceps is contracted, force the head of the humerus out of its normal position.

The literature on this subject throws no light on the importance of the biceps tendon in these cases. Briddon, Reid,[3] Adams,[4] and J. H. Brinton,[5] who have reported operated cases of old unreduced posterior dislocations of the shoulder, do not mention the biceps tendon and do not speak of rupture of the transverse humeral ligament.

TYPE OF OPERATION.

Resection of the head of the humerus has been the operation performed in three out of the four cases of unreduced posterior dislocations of the shoulder operated upon. Briddon and Adams report "good" results following resection in their cases; while Reid states that three months after the operation abduction was limited, but the patient had been benefited by the operation. J. H. Brinton produced a fracture of the humerus, with a resulting false joint, in his case and reports a "good result." All of these reports are indefinite regarding the pathology of the dislocations, the description of the operations, and the results obtained.

A study of the reports of unreduced dislocations of the shoulder—other than the posterior variety—suggests that operation is indicated in posterior dislocations when bloodless methods fail to accomplish reduction, and in all cases in which it can be determined that the biceps tendon has been torn from its groove; and that reduction is preferable to excision or other operative procedures. The subcutaneous division of adhesions, recommended by the French, should be supplanted

by free exposure of the parts. Of the many methods advised in operating on these cases, the one turning up the deltoid in the flap gives the best exposure of the shoulder joint and the surrounding structures. The straight or slightly curved incisions are preferred by some operators. The long anterior incision seems to be the one of choice in treating old unreduced anterior dislocations of the shoulder.

I was surprised that I could find the reports of only four cases of old unreduced posterior dislocations of the shoulder treated by operation.

CASE I.—Briddon reports a subspinous dislocation of the head of the humerus in which manipulation failed to accomplish reduction. The head of the bone was resected. The result is described as being "good," but no details are given.

CASE II.—Reid treated an old unreduced posterior dislocation of the shoulder by resecting the head of the humerus. Three months later the arm was freely movable with the exception of abduction which was limited.

CASE III.—Adams resected the humeral head in a posterior dislocation of the shoulder that could not be reduced by bloodless manipulation. The patient, who was a porter, was able to perform his duties without difficulty a few months after the operation was performed.

CASE IV.—Brinton, being unable to reduce an old posterior dislocation of the shoulder, exposed the joint by using a V-shaped incision. Reduction was not accomplished, but a fracture was produced below the head of the humerus making a false joint. He reports a "good result."

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[3] Reid. Quoted by Souchon. Case reported in 1887.
[4] Adams. Royal Medical and Surgical Society, March, 1888.
[5] Brinton. Dunglison's College and Clinical Review, Nov., 1897.

PARTIAL LOSS OF THE TIBIA REPLACED BY TRANSFER OF THE FIBULA, WITH MAINTENANCE OF BOTH MALLEOLI OF THE ANKLE.*

BY JAMES S. STONE, M.D.,

OF BOSTON,

Surgeon to the House of the Good Samaritan; Assistant Surgeon to the Infant's Hospital; Junior Assistant Surgeon to the Children's Hospital; Assistant in Surgery in the Harvard Medical School.

W. B., a boy five years old, had in June, 1904, an acute dissecting periostitis beginning at the lower end of the right tibia and in six days stripping the bone nearly as far as the patellar tubercle. Owing to sloughing of the periosteum after the removal of the shaft the tibia regenerated very imperfectly. Nine months after the onset of the trouble the bone had reformed for about an inch and a quarter from the upper end. There was then a gap of about an inch, below which was a thin strip of bone two inches long, reaching down to within about half an inch of the lower epiphysis from which a little new bone had grown upward. The fibula was normal. The appearance is shown well in the radiograph taken at that time (Fig. 1).

In August, 1905, thirteen months after the onset of the trouble, the boy was admitted to the General Surgical Service of the Children's Hospital for operation. Since ten weeks after the trouble began he had been going about with a plaster bandage and Thomas knee splint.

The attachment of the upper end of the fibula had become loose so that the head of the bone could be shoved upward slightly and the foot could be moved inward for about two and a half inches. There was marked shortening of the leg, varying with the position in which the foot was held. The foot was a little smaller than on the sound side. The fibula had become somewhat hypertrophied, particularly at the middle of the shaft. All wounds were solidly healed (Fig. 2).

It was decided to transfer the fibula into the gap in the tibia.

* From the General Surgical Service of "The Children's Hospital," Boston, Mass. (Service of Drs. H. L. Burrell, H. W. Cushing, and J. S. Stone.)

The upper end was transferred first. A vertical incision about three inches long was made directly over the lower end of the upper sound portion of the tibia. The cut was made directly through the periosteum which was separated on the fibular side for a vertical distance of about two inches. The muscles were then separated along the interosseous membrane until the fibula at the same level was exposed. In order to reach the fibula more readily a second incision about an inch and a half long was made directly down onto the bone on the outside of the leg. At a point about two inches from the upper end the fibula was then cut across with a chain saw. The upper end of the lower fragment was then inserted into a mortise cut in the tibia. This mortise was cut at a level slightly lower than that at which the fibula was cut across in order to gain length if possible. The periosteum was reflected from that side of the fibula which rested in the mortise. The reflected periosteum of tibia and fibula were then sutured together with chromic catgut to maintain close apposition, and the reflected periosteum of the tibia was further sutured as a cuff around the upper end of the fibula to hold it more securely in position. The muscles were then allowed to slip back into their former positions as far as possible. A few dead spaces were closed by catgut sutures uniting the fasciæ. The incisions were closed without drainage. A sterile dressing and plaster bandage were applied.

An X-ray taken through the plaster three weeks after operation showed that the position of the bone had not changed. After four and a half weeks the boy went to the Convalescent Home. Eleven weeks after operation the plaster was removed. Moderately firm union had occurred. The X-ray showed the upper end of the fibula had been driven upward slightly into the medullary portion of the tibia. A new plaster was applied.

The boy was readmitted to the hospital in January, 1906. At that time the union between the upper end of the tibia and the fibula had become absolutely solid and the shaft of the fibula had materially increased in thickness (Fig. 3).

Five and a half months after the first operation a longitudinal incision was made anteriorly over the outer part of the lower end of the tibia. The bone was exposed. By careful dissection the lower end of the fibula was then exposed through the same incision and with a chisel it was split horizontally for a distance of

nearly four inches. Great care was taken to avoid separating the periosteum from either half of the bone. At the lower end of the split made in the bone the inner half was cut across transversely at the level of the upper part of the remaining lower epiphysis of the tibia. A small pocket was then cut in the cartilage covering the end of the tibial epiphysis just large enough to receive the inner half of the fibula. The inner half of the fibula was then sprung into its new position in the tibia. In doing so the outer half was broken at its upper end but was still held in place by the periosteum. The inner half remained intact and was retained in its new position by the tension of the muscles. The fascia forming the muscular sheath was sewed with catgut and the skin was closed without drainage. A sterile dressing and plaster of Paris bandage from the toes to the thigh completed the dressing. Three weeks after operation the child was sent home with the plaster bandage not disturbed. An X-ray showed that the bones remained in place.

After three months the plaster was removed. A small granulating spot was found at the lower end of the incision. Bony union was solid. Five days later a small spicule of necrotic bone about three-quarters of an inch long was discharged. After this the skin healed solidly. A month later the boy began to walk on his leg, and ever since has used it without restraint (Fig. 4).

NOTE.—For the series of radiographs which show the conditions better than words can express them I am indebted to Dr. A. W. George, the radiologist of the Hospital.

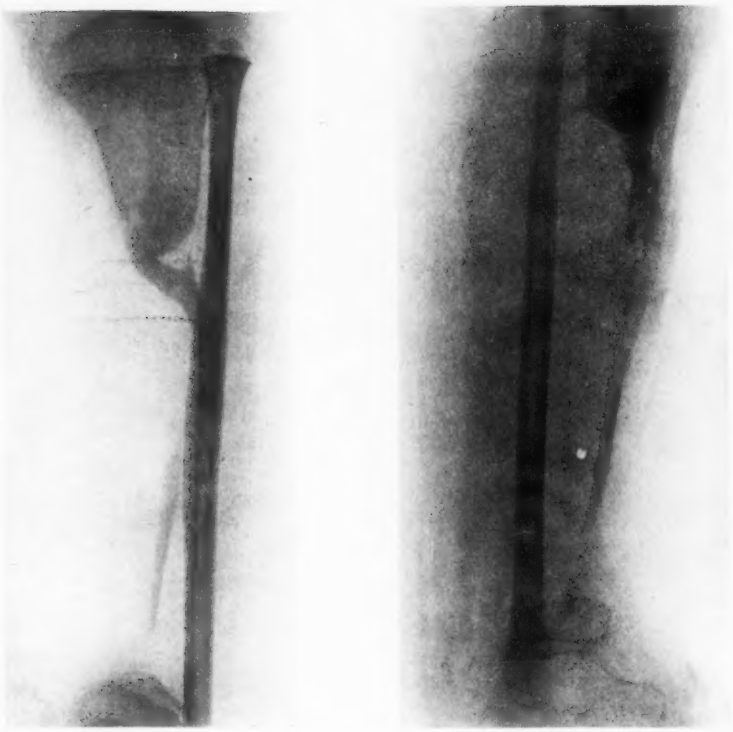
The problem presented in this case was the restoration to usefulness of a leg in which the fibula was sound, the upper end of the tibia was sound, and in which the lower epiphysis of the tibia remained, but without any shaft above it for a distance of 12 cm., nearly five inches. As might be expected a talipes varus was developing because of the lack of support for the inner side of the foot. The utilization of the fibula to take the place of the tibia seemed the obvious means of relief. The hypertrophy of the fibula, shown in the second set of radiographs, which came on when no weight was being borne upon the leg and when the boy was walking about with a Thomas knee splint, confirmed the hope that the hyper-

FIG. 1.

Antero-posterior view. Lateral view.

Radiographs taken nine months after the removal of the shaft of the tibia. The amount of regeneration is well shown.

FIG. 2.



Antero-posterior view. Lateral view.

Radiographs taken a year after the removal of the shaft of the tibia. They show that no further regeneration of bone had occurred since the preceding X-rays were taken. They show, however, the beginning hypertrophy of the shaft of the fibula, most pronounced about the middle.

FIG. 3.

Antero-posterior view. Lateral view.

Radiographs taken five months after the first operation. Solid union but slight impaction of fibula into medullary cavity of tibia.

trophy would continue if the functional use of the bone were increased.

The operative procedures especially in the first step were easy. The field of operation was made bloodless by a tourniquet which, however, was removed before the wounds were closed. The utmost care was taken to avoid injury to any nerves or vessels. In cutting across the upper end of the fibula great care was taken to avoid injury to the periosteum. In cutting out the mortise in the upper part of the tibia advantage was taken of an existing hollow in the bone, but the utmost pains were taken in separating the periosteum to avoid tearing it. A side of the fibula bared of periosteum was placed in a freshly cut mortise in the tibia. Bare bone was thus placed next bare bone, while periosteum was sutured to periosteum. A mistake was made in cutting the hole in the tibia a little too deep. The fear was that the fibula might not remain in its position. The fact was that the muscular pull crowded the bone upward into the medullary cavity. If the experience in this case is of value it would seem wise to cut the mortise only so deep that the cortical layer of the entering bone cannot sink inside the cortical layer of the receiving bone.

The second step was more difficult than the first. It was necessary to maintain connection between the shaft of the fibula and the external malleolus. If this was lost the outer side of the ankle joint would have been seriously weakened. At the same time it was necessary to bring a portion of the fibula above the lower epiphysis of the tibia. The greatest care was used in splitting the fibula. The periosteum was first cut with a sharp knife. Then in part with a small chisel, in part with a stout knife the bone was divided. Each half of the bone had a thickness of only 4 mm., scarcely over an eighth of an inch, yet in separating them for a distance of about three inches, 8 cm., it was essential that the periosteum remain adherent to each portion and that an equal thickness of each part be maintained throughout. It was planned to spread the halves without breaking either. This proved impossible. Fortunately the outer rather than the inner half gave way

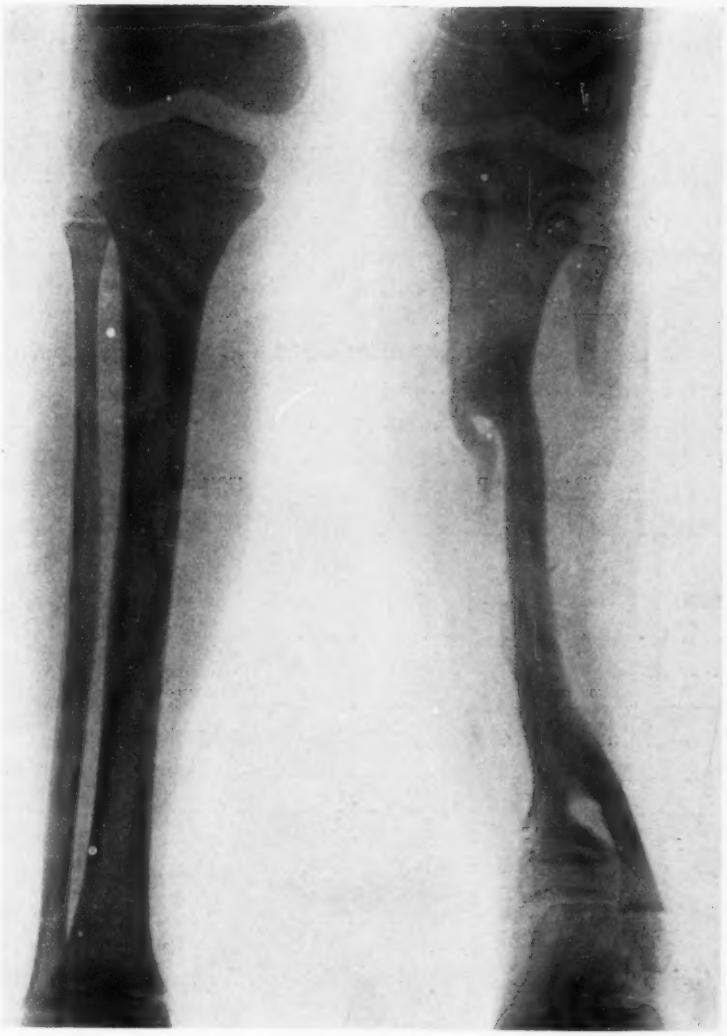
close to the upper end of the split between them. In another case it would seen wise to insure a break in the outer half at this point rather than run the risk of breaking the inner half or the outer half at a lower level. The promptness and the extent of the new bone formation from each of the halves were surprising. The trifling amount of necrosis was gratifying.

The continued increase in the size of the transferred bone is most striking, and corresponded in amount with the freedom of use which was allowed. The last radiograph (Fig. 5) was taken after the boy had been using the leg for nine months without any restraint whatever and without any discomfort or disability at all.

In any similar case more prompt transfer of the bone would seem advisable. Nothing was gained by the delay. The length of time allowed between the steps of the operation might also have been shortened.

The result is one of perfect functional usefulness. There is a shortening of 4.2 cm. measured in the radiograph (1⅝ inches) which corresponds with the ordinary clinical measurements. The lower ends of the tibia and fibula are growing symmetrically. While it is not possible to say absolutely how great an interference with growth there may be in the future the present indications are that it will be very slight and will not interfere at all with normal functional use.

FIG. 4.



Radiograph taken of both legs nearly two years after the removal of the shaft of the tibia, about four months after the fibula was split and the inner half was inserted in the tibia. There is a shortening of exactly 4. cm. (one and a half inches). About one half of this is due to retarded growth, while the other half is due to a crowding up of fibula into the medullary cavity of the tibia.

Note the hypertrophy of the transferred portion of the fibula and compare it with the atrophy of the upper useless end of the fibula. Note the thickening and firm union of the lower divided halves of the fibula. The normal relations of the malleoli and lower end of the tibia are retained. The spot from which the small sequestrum was discharged is shown at the inner side of the bone just above the lower epiphysis of the tibia.

FIG. 5.

Radiograph taken in February 1907, two years and eight months after the removal of the tibia,—nine months after the preceding radiograph. The tremendous increase in the diameter of the transferred fibula occurring under the stimulus of functional use is strikingly shown. Accurate measurements of the radiographs show that the tibia of the normal side has grown 1.1 cm. in length in nine months while the bone on the other side has grown .8 cm. in the same period. In other words, the interference with growth at the lower epiphyseal line of the tibia has been only .3 cm. in nine months. There has been no change in the relations between the lower epiphyseal lines of the tibia and fibula. There is no tendency toward the development of a talipes varus or talipes valgus.

FRACTURE OF THE TARSAL SCAPHOID BONE.

WITH REPORT OF THREE CASES.

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FRACTURE of the tarsal scaphoid bone is of infrequent occurrence. The standard text-books on fractures do not mention it, though Bloodgood, writing in Saunders' Medical Hand-atlas, recognizes fractures of the tarsal bones other than the astragalus and os calcis.

Prior to the advent of the Röntgen-rays, Kohlhardt [1] reported a case of fractured scaphoid. Later, Bahr [2] recognized luxations of the bone, and reported 7 cases. The accuracy of these diagnoses is considered doubtful by later writers. In 1905, Bergmann [3] described 3 cases, and proved his diagnosis skiagraphically.

The scaphoid bone, situated at the inner side of the tarsus, articulates behind with the astragalus, and in front with the three cuneiforms. The number of joints into which it enters, combined with the important position of the bone in the plantar arch, make injuries to it seriously disturb the integrity of the latter structure, and render the prognosis very guarded.

Fractures of this, as of the other tarsal bones, usually occur after falls from a height, the patient landing on the toes with the foot in plantar flexion. This indirect force transmitted from above presses the bone between the astragalus and cuneiforms, and tends to drive it forward. Owing to its bracing by the plantar ligaments, its close articulations, and its great dorso-plantar diameter, the bone is usually crushed before this takes place. Isolated dislocation has not been observed since cases began to be studied by the X-ray. With greater force the fragments slip forward under the tendons on the dorsum of the foot, and the astragalus is pushed into their place.

On physical examination, the foot is seen to be swollen

and apparently broadened. Bergmann, in his three cases, found shortening of the inner edge of the foot, amounting to about 0.75 cm. Tenderness and crepitus can usually be elicited anterior to and a little below the malleoli. In cases with dislocation, the displaced fragments can be felt as a prominent knuckle on the dorsum of the foot. The usual clinical diagnosis is fracture of the astragalus.

The best method of diagnosis is by skiagraph, taken as usual for lateral views of the foot, with the external malleolus resting on the plate. A fair view of the bone can also be obtained in the antero-posterior direction. The principal line of fracture is found, as a rule, to follow the long axis of the bone, the two resulting fragments being further comminuted and displaced forward or inward, following the lines of least resistance. The normal foot should also be skiagraphed for comparison. The importance of this is illustrated by Momburg's [4] case. Disability was claimed one year after a slight injury. A skiagraph showed the scaphoid to consist of two pieces. There was, however, no effort at callus formation, and a control picture of the other foot showed a smaller piece in a similar location. The patient being overweight and showing in addition flattening of the arch, on both sides, the symptoms were ascribed to this and the indemnity was not granted. This whole question of supernumerary bones in the tarsus requires further investigation. Another example is seen in the so-called "os trigonum tarsi."

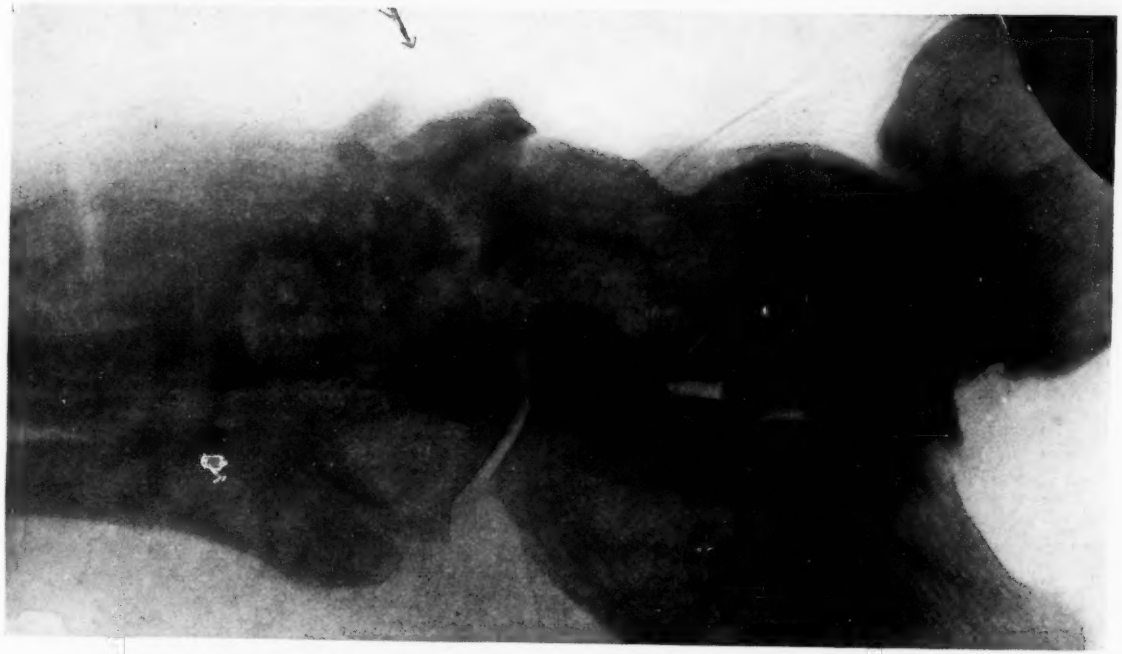
Treatment should aim first at the reduction of the fracture. For this Bergmann recommends the following technique: under ether the toes are grasped and extended, the foot flexed plantarward and abducted. This manœuver tends to increase the distance between the astragalus and the cuneiforms, and pressure on the dislocated fragments may now replace them. If the irregularities of the fragments make this impossible, Bloodgood [5] suggests an incision for reduction.

The apparatus used should have for its primary object the support of the arch. Bergmann rejects the complete cast as inapplicable on account of the swelling in early cases, and rec-

FIG. 1.

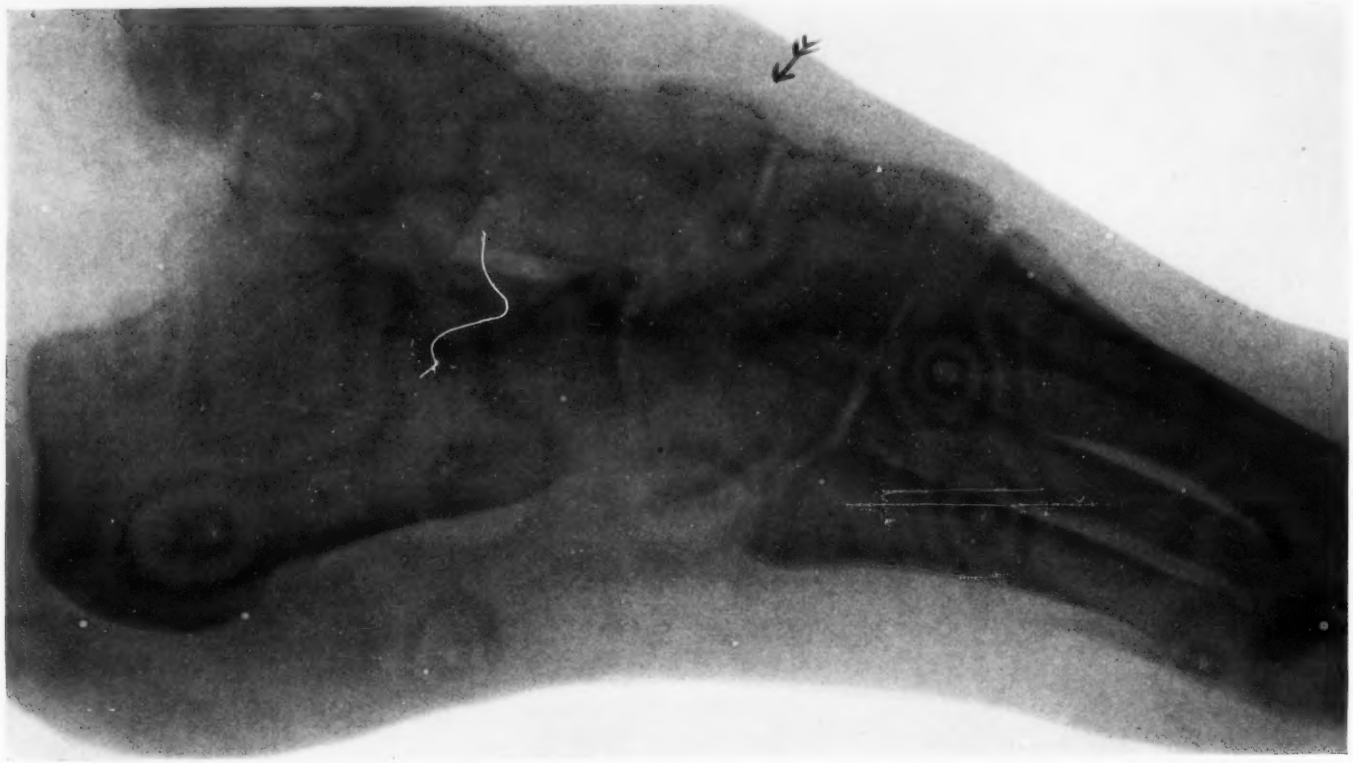
Case 1.—Note forward displacement of scaphoid, and relation of astragalus.

FIG. 2.



Case II.—Note comminution and forward displacement of fragments.

FIG. 3.



Case 3.—Showing longitudinal fracture of bone.

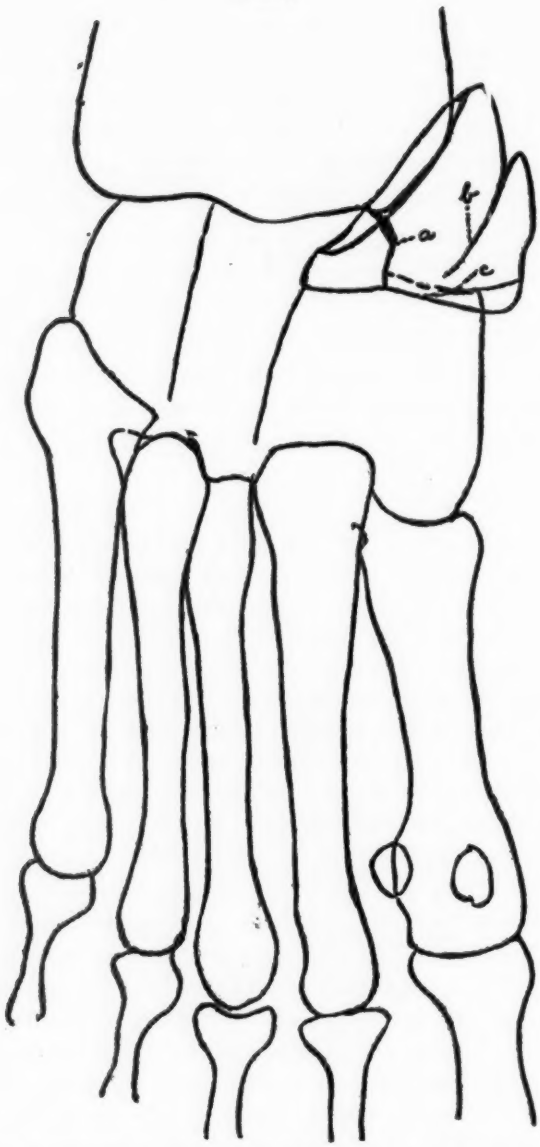
ommends a strong plantar splint of plaster, extending from the toes over the sole to the upper third of the leg, and well molded over the arch. Over this is applied a firm bandage with much wadding. This dressing allows of daily removal of the bandage for massage and bathing of the foot, a procedure which this author considers very important. After firm union has been obtained, a flat-foot plate should be worn for a long period.

Prognosis should be guarded in every case. Traumatic flat-foot, with its accompaniments of pain, edema, and varying disability, is very likely to develop. Especially in the unreduced cases the ultimate function is bad. It must be borne in mind that by this fracture the capability of two of the great weight-bearing joints of the foot, the talo-navicular and naviculo-cuneiform, is practically destroyed.

Case I.—C. H. B., lineman, aged 30, fell from a telegraph pole in October, 1905, landing heavily on both feet. He was brought fourteen miles to the Worcester City Hospital, where, a few days later, skiagraphs were taken. These showed on the right a badly comminuted ankle-joint, tibia, fibula, and astragalus all being involved. On the left, the scaphoid was broken into several pieces and driven forward under the tendons on the dorsum of the foot, the astragalus being shoved forward to take its place. Treatment consisted in reduction and immobilization in plaster, continued six weeks. Toward the end of this time flat-foot plates were applied to both feet. On December 17 the patient left the hospital, the record stating " Motions at ankle good," and I have been unable to trace him. If this case were seen fresh to-day, I should recommend Bloodgood's operation (Fig. I.)

Case II.—N. F., teamster, aged 23, stepped backward into a hole in a roof, and fell about 20 feet to a pile of bricks, striking on both feet with knees semi-flexed, on October 28, 1906. The left ankle at once became swollen and painful, and he was taken to the Worcester City Hospital, where swelling, ecchymosis, tenderness, and crepitus below the malleoli were noted, and a diagnosis of fractured astragalus made. A skiagraph taken next morning showed the following condition: Scaphoid comminuted with slight forward dislocation of fragments. Astragalus pushed slightly downward. (Fig. II.)

FIG. 4.



Case III.—Antero-posterior view. (tracing). (*a*) Principal fracture line. (*b*, *c*) Lines of fissure.

Plaster was applied, and continued for about four weeks, after which patient was allowed to use his foot.

On February 14, 1907, three and a half months after the injury, his condition was as follows: Marked thickening at the site of the bone on the dorsum and inner side of the foot, apparently due to callus formation. Motions at the ankle are free and painless, except inversion, which causes some pain. Patient says that the foot easily becomes tired. After a hard day's work it becomes edematous and cyanotic, and the veins become prominent. Pain appears at the site of the fracture, sometimes radiating up the leg, and severe enough to interfere considerably with his present work as collector.

A skiagraph taken at this time showed the bones about as in the first one, with some loss of detail, probably due to callus. A flat-foot plate, designed to hyper-correct the evident flattening of the arch, was applied, with immediate and continued relief. The patient is still wearing it (May 4).

CASE III.—J. J., nurse, aged 21, leaped from a window in a fit of melancholia on March 4, 1907, striking with both feet on the frozen ground. She afterward complained of pain in the right foot, and a bandage was applied, but little else was done until four weeks later, when Dr. B. T. Burley was called as consultant on the nervous symptoms. He examined the foot, and, having heard cases I and II reported before a local society, made the clinical diagnosis of fractured scaphoid. By his advice the patient was sent to Memorial Hospital and skiagraphs taken (Figs. III and IV). Physical examination showed marked tenderness on the dorsum and inner side of the foot, over the site of the bone. No crepitus could be elicited.

The skiagraphs showed the longitudinal fissure line with unusual distinctness, there being also some comminution of the fragments.

A plaster cast was applied from the toes up, and worn two weeks, when it was replaced by a bandage. At the present writing (May 4) the foot appears normal, but the patient is still on crutches, and refuses to put it to the floor. The mental condition renders careful examination difficult.*

* July 27. Patient's mental condition has improved, and she reports foot "as well as ever, except for swelling after unusual exertion." Is wearing no apparatus.

I am indebted to Drs. Homer Gage, Marsh, and Burley for the privilege of reporting these cases, which occurred on their services. The histories are compiled from the records of the Worcester City and Memorial Hospitals.

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[5] Bloodgood. Loc. cit.

TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY.

Stated Meeting, May 8, 1907.

DR. JOSEPH A. BLAKE, President *pro tem.*

STAB-WOUND OF THE SPINAL CORD.

DR. WILLIAM G. LE BOUTILLIER presented a boy, seventeen years old, a plumber, who was admitted to the J. Hood Wright Hospital on March 27, 1907, in the service of Dr. Howard D. Collins, with the history that shortly before his admission, during a quarrel, he was stabbed in the back of the neck. He dropped to the pavement, but did not lose consciousness.

The boy was immediately brought to the hospital, and upon examination he was found to be conscious, but in a condition of considerable shock. He was unable to move either his arms or his legs. There was a small incised wound in the left occipital region. This wound, from which only a few drops of blood had escaped, was probed by the assistant house surgeon, and he stated that the probe passed along the occipital bone and then downward and inward to a depth of about four inches, extending to the cervical vertebræ. The wound was about half an inch in length. When Dr. Le Boutillier came on duty, there was still complete paralysis below the clavicle. The pupils were equal, and reacted to light and accommodation. There was no strabismus nor facial paralysis. The tongue did not deviate. The voice was husky, and the patient could not speak above a whisper. There was no impairment of deglutition nor articulation. There was no bleeding from the ears, nose or pharnyx. The left trapezius and sterno-cleido-mastoid muscles were paralyzed, and the patient was unable to move his neck. The head was drawn slightly to the right side. There was paralysis of the external respiratory muscles on the left side. The patient breathed entirely

with the right side of the chest. There was no diaphragmatic respiration on the left side. There was complete flaccid paralysis of the left arm and leg, with spastic paralysis of the right arm and leg. The knee-jerk and cremasteric reflexes were absent on the left side; about normal on the right side. There was no loss of tactile sensation on either side of the body or in the extremities. No priapism. No apparent injury to the vertebral column was determined. Abdominal and thoracic viscera negative. Temperature on admission, 97.8; pulse, 84; respirations, 26.

The patient was kept in bed, and external heat was applied. He twice vomited small amounts of undigested food, but complained of no pain. From the onset, defecation and micturition were involuntary. For the first few days after his injury, there was no noticeable change in the symptoms, except profuse frothy expectoration lasting about a week. The wound in the neck healed on the second day. On April 2, the patient had complete loss of motion as noted above. He responded to touch everywhere equally well. Temperature and pain sensations were somewhat disturbed, especially on the left side of the body. Along the upper part of the neck and under the chin there was quite a definite area of hyperæsthesia. On the upper left part of the occipital region there was a small area, about two inches in diameter, of apparently absolute anæsthesia. There was some dysphagia, and inspection showed some paralysis of the pharyngeal muscles. The right pupil was larger than the left.

On April 8 the patient's general condition was good. There was no decubitus. There had been no improvement in the paralysis. The reflexes which had hitherto been absent, were now present and exaggerated. About April 17th there was beginning return of voluntary motion in the feet and fingers. On April 26th the patient first became conscious of a desire to urinate, and he began to acquire slight power in its control. Defecation was still involuntary. He was now able to flex the right leg to a right angle with the thigh, and the left forearm nearly to a right angle. Power to rotate the legs was slight, but equal. The power of grasp in each hand was very slight, and apparently equal. The patient now responded accurately and normally to pain and temperature stimulation on the left side of the body, but there was still considerable confusion on the right side.

On May 2, 1907, with some slight support to the arm, the

patient could now carry his left hand almost to the mouth. The ability to extend the hand was not so good. The right thigh could be well flexed on the abdomen, and the leg on the thigh. Power in the right arm and left leg was only slightly increased, and was very weak compared with that in the other two extremities. There had been no trophic disorders at any time, and the general condition of the patient was excellent.

Dr. John A. Hartwell, in speaking of the differential diagnosis between a direct stab-wound of the spine and hæmorrhage in the case shown by Dr. Le Boutillier, said there were several points that favored the latter view. He could recall three cases in which a diagnosis of subluxation of the spine had been made on account of immediate paralysis following the injury in which the symptoms subsequently proved to be due to hæmorrhage. In all those cases, the paralysis was almost instantaneous, and the fact that Dr. Le Boutillier's patient was immediately paralyzed did not throw out the diagnosis of hæmorrhage.

The second argument against a possible severance of the cord in this case was the rapid improvement; this had occurred within three weeks, which was much sooner than would have been expected even after the suture of a nerve with a neurilemma, while it would certainly be unusual in the spinal cord, which had no neurilemma, upon which regeneration depended.

Dr. Hartwell said the direction of the stab-wound in this case was also inconsistent with the idea that the cord itself was wounded. He was inclined to attribute the paralysis to the pressure effects of a hæmorrhage. The unusual distribution of the sensory symptoms also suggested the possibility of a neurosis.

Dr. Theodore Dunham referred to one case coming under his observation in which the symptoms were somewhat similar to the one shown by Dr. Le Boutillier. The patient was a boy of nine years with a spina bifida. He had had several attacks of paralysis of varying degrees, the effects of which had passed off in the course of time. One day, while seated in a wheeled chair, he suddenly fell out, and when he was picked up he was almost completely paralyzed, although he still had control of one arm. He was brought to the hospital and for three or four days was in a more or less stupefied condition, and when that passed off, his paralysis was still more evident. After about three weeks there was slight motion in the paralyzed limbs, in which he had

since then gradually regained power. There was no history of trauma, and the case was regarded as one of hæmorrhage into the cord.

STRANGULATED INGUINAL HERNIA IN A SEVEN WEEKS' OLD INFANT.

DR. LE BOUTILLER presented a boy, seven weeks old, who was admitted to the J. Hood Wright Hospital on April 22, 1907, at 5.30 P.M., with the history that he had a "lump in his groin." The mother stated that on the day prior to his admission he had had no stool and had cried considerably, as though in pain. Upon examination she found a swelling in the right groin which seemed tender. Toward evening the child began to vomit and continued to do so at intervals during the night and the following morning.

Upon examination at the hospital, the abdomen was rather rigid, and in the lower right inguinal region there was a slight fulness extending over Poupart's ligament and down into the scrotum, which was swollen, reddened and tender. The mass itself was fairly soft, and felt as though it contained fluid or gas, and was apparently connected by a pedicle with the abdominal cavity.

The patient was immediately removed to the operating room, and a three-inch incision was made from just below the anterior superior spine, passing obliquely downward to just below the inner part of Poupart's ligament. The skin and fascia were retracted, and the protruding hernial sac freed from the cord and opened. It contained no fluid, but about five inches of small intestine, which was adherent to the end of the sac. The adhesions were broken up, and a small area of the gut, about one-quarter of an inch in diameter, which was lustreless, black and almost gangrenous, was inverted with Lembert's sutures, so that the knuckle made by turning in the affected area ran transversely to the long axis of the gut. The gut was then returned to the peritoneal cavity and the sac excised, one chromic catgut suture being inserted to approximate the aponeurosis about the external ring. The wound was closed with interrupted sutures.

Following the operation, the child was restless and cried a good deal during the night, and had several slight attacks of vomiting. On the afternoon of the day following the operation the temperature suddenly rose from normal to 104, and then

as rapidly returned to normal. The wound healed by first intention, and after the first day the child nursed and slept well, and seemed comfortable. The bowels moved regularly once or twice daily, and there was no evidence of any intestinal discomfort or trouble. The patient was discharged cured on April 27, 1907.

A PRELIMINARY REPORT ON THE TREATMENT AND CURE OF CANCER BY THE USE OF THYMUS GLAND.

Dr. Frederick Gwyer read a paper with the above title for which see page 86.

Dr. Blake, after examining the patient, said there was still a distinct mass over the clavicle and another in the left pectoral region.

Dr. John Rogers said he had had quite a little experience with the use of these foreign substances, and one serious difficulty he had encountered was that a human being would acquire immunity to calf thymus in a moderately short period of time, and it was necessary to increase the dose rather rapidly.

Dr. Gwyer said the tumor in the pectoral region referred to by Dr. Blake was an enlarged gland which was formerly as large as his thumb, but had now almost disappeared. The other mass might possibly be fat.

In reply to Dr. Rogers, the speaker said that while perhaps a patient might acquire tolerance to the administration of the gland, he thought that point would not be reached before the onset of the auto-intoxication which would necessitate an intermission in the course of the treatment. During this period of rest, it was probable that the acquired tolerance would again be lost, and treatment would again become effective. Personally, Dr. Gwyer said, he had not seen this acquired tolerance in any of the cases in which he had given the thymus. The gland seemed to have a selective action on the cancerous growth, and he knew of no other remedy or treatment which produced such a rapid and marked change in the clinical appearance of the lesions. A month ago some of the enlarged glands in the case he had shown were visible across the room; to-day they could scarcely be felt.

TUBERCULINS AND THE TUBERCULO-OPSONIC INDEX.

Dr. Theodore Dunham read a paper with the above title for which see page 596.

DR. ROGERS said he had employed this method of treatment to some extent in tubercular cases, and was very well satisfied with it. There was considerable difference of opinion in regard to the value of the opsonic index, and for a long time, Dr. Rogers said, he had shared in the feeling of scepticism regarding it. Since then, however, he had had practical evidence of its efficacy in a case of tuberculosis of the glands which had previously been operated on a number of times, and in which the glands rapidly disappeared under the use of tuberculin. There were many cases of tuberculosis of the glands and bones and joints and some of visceral tuberculosis which were perfectly hopeless from a surgical point of view, and it was in that class of cases that this treatment should be given a thorough test. The speaker said he had resorted to it in two cases of Pott's disease, with psoas abscesses and discharging sinuses, fever, etc. He began by giving these children a solution which was made by mixing 0.000001 gm. of ground tubercle bacilli (Koch's "TR") in 1 c.c. of sterile water. Of this mixture a dose of 1 minim was given on the first day, and increased 1 minim each day. The opsonic index was not taken, and the speaker said he did not think that was necessary. In these two cases the dose was gradually increased, and by the end of the second week the discharge from the sinuses had almost entirely ceased. A week later the children were up and running about the wards, and showed other signs of improvement, although the sinuses had not entirely closed.

It was very necessary in these cases, Dr. Rogers said, to keep track of the temperature, because with an elevation of the temperature the symptoms became aggravated and the discharge from the sinuses increased.

DR. BLAKE said it was well known that the treatment of pulmonary tuberculosis with tuberculin had been carried on for some time without the help of the opsonic index for the purpose of determining the proper dose, and very good clinical observers had made the assertion that it was not necessary to have the opsonic index in order to determine the amount of tuberculin to be given. He referred to a case of mixed tubercle and staphyloccocus infection of the cervical lymph nodes where the tissues had become undermined with burrowing sinuses in which a thorough course of treatment with vaccines had had no effect whatsoever.

DR. DUNHAM said he had treated a number of tuberculous children with tuberculin in small doses without taking the opsonic index, and they had all done surprisingly well as regarded their general health. One was a rather bad case of tubercular peritonitis which had been operated on several times, and which afterwards did exceedingly well under the tuberculin treatment. He had also tried the method in cases of tuberculosis of the joints and in tubercular sinuses. He had become quite enthusiastic regarding the treatment, and had a strong feeling that it could be carried out almost as well without the opsonic index as with it. While the determination of the opsonic index was very desirable, the process was a laborious one, certainly in hospitals where a number of these cases were under treatment. In dealing with obscure cases, the recognition of tuberculosis by the opsonic index would be exceedingly useful.

AN INFLAMED APPENDIX REMOVED FROM A STRANGULATED INGUINAL HERNIA.

DR. LE BOUTILLIER showed a specimen, which he had removed from a twelve weeks' old baby who had a congenital right inguinal hernia which had become strangulated. The hernial sac was found to contain cæcum and an inflamed appendix which was about an inch and a half long.

The history of the case was that the hernia had been irreducible for about ten days. The hernial tumor was about the size of a walnut. The abdomen was distended and tender, and there was fever and vomiting. Three days before operation the attending physician had succeeded in reducing the hernia, but in spite of this the symptoms of vomiting and pain persisted. The hernia again descended about eight hours before the operation was done, and the scrotum was exceedingly red and tender. Recovery was uneventful.

BOOK REVIEWS.

SURGERY OF GENITO-URINARY ORGANS. By J. W. S. GOULEY, M.D., New York City. Rebman Company, New York, 1907.

After fifty years of surgical work, dealing with a class of patients in Bellevue Hospital in which urological disease is rampant, Dr. Gouley has gathered together in this volume the experience of these years. Dr. Gouley has written many papers upon various subjects but this is the first book which has been published by him. To the beginner in the study of the diseases of the genito-urinary organs, the book is of special value because it treats of the subject almost entirely from a clinical standpoint. The work consists of brief annotations on the nature, diagnosis and treatment of some of the diseases of the genito-urinary organs that come within the province of surgery. The book is by no means a systematic treatise on genito-urinary surgery; it treats simply of the surgical diseases of the urethra, prostate and bladder, and is practically a collection of the papers read and published by the author at various times during the course of his work. The book is delightful reading to one interested in this branch of surgical endeavor and it abounds in truths and practical suggestions, although the domain of the clinical pathologist has been sadly but purposely neglected. Those who are entering upon this work would do well to pause and read the conclusions of a surgeon of Dr. Gouley's vast experience.

PAUL PILCHER.

SURGICAL DISEASES OF THE CHEST. By CARL BECK. Philadelphia: P. Blakiston's Son & Co., 1907. ix, 371 pp. Illustrated 8vo.

A review of the book naturally falls into three portions:—

1. The Anatomy.

2. Those surgical conditions that occur in this region but also in other parts of the body.

3. The conditions that occur in the chest region exclusively and merit a special treatise.

The author devotes one-seventh of the book to anatomy. This part conforms to the standard text-books on anatomy and the illustrations are from Morris.

The second part takes up in a superficial way such diverse subjects as Hodgkins disease, spina bifida, kyphosis, fractures, carbuncles, burns, etc., and the ordinary details of the sterilization of the surgeon's hands. The author also considers subphrenic abscess and cervical rib, which are not strictly diseases of the chest.

In the third portion of the book, to which the surgeon naturally turns, the subject of pyothorax is treated at length. The author advises the use of his special periosteotome, rib shears and pleural speculum. After a subperiosteal resection of the rib and slow evacuation of the pus, he introduces the finger, or sponges on holders, or a blunt spoon through the pleural speculum into the pleural cavity to remove all fibrinous masses and irrigates with salt solution. He then stitches the costal pleura to the skin with four silk sutures and packs the cavity with several yards of a narrow strip of 3 per cent. iodoform gauze, dispensing with the use of rubber drainage tubes. Then follows an extensive argument to prove that his method is more satisfactory than those in general use, in the ordinary acute cases.

For chronic pyothorax he gives the history of the development of the more radical operations now employed to combat this condition. The other surgical intra-thoracic diseases he treats in brief.

The book closes with a consideration of the diseases of the mamma.

The X-ray illustrations are in part new and in part from the author's recent work on the "Roentgen Ray in Diagnosis."

WALTER C. WOOD.

CORRESPONDENCE.

FRACTURE—DISLOCATION HEAD OF HUMERUS.

To the Editor of the Annals of Surgery:

Sir:—It may interest your readers to know in reference to Dr. Keen's case—June, 1907, p. 945—of fracture of the anatomical neck of the humerus with dislocation of the head into the axilla, that in 1893 I recorded two cases in the Transactions of the Pathological Society of London, Vol. XLIV, p. 128.

The head in each case was removed from the axilla by operation—one by Mr. Croft and one by myself, and both specimens are now mounted in the Museum of St. Thomas's Hospital. The illustrations published in the Transactions are almost identical with that of Dr. Keen's published in the Annals of Surgery for June, 1907. In 1893 we had not the advantage of the X-rays, but there was not the slightest difficulty in recognizing the nature of the injury.

Yours faithfully,

H. H. Clutton,
2 Portland Place, West,
London, England.

July 26, 1907.

EDITORIAL NOTE.

POPLITEAL THROMBUS.

The figure on page 347 "showing thrombus in popliteal artery" should have been inserted on page 363.

TO CONTRIBUTORS AND SUBSCRIBERS.

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